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Dual-Purpose Optical Prints

Theory of Parallax Barriers

Direct-Vision Stereo Screen

Automatic Torque Controller

Three-Phase From Single-Phase

Continuous Arc Projector Meter

Use of a Rotating-Drum Camera

Navy Training Film Production

Nonsilver Photographic Process

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Dual-Purpose Optical Sound Prints

By C. E. BEACHELL and G. G. GRAHAM

This paper describes a method of recording and printing two separate sound tracks within the normal single-track area for 16mm or 35mm release prints. A projector conversion kit for reproducing the double tracks separately or simultaneously is also discussed. This technique has possible application in reducing distribution costs on foreign versions and in the educational and television fields.

In view of the greatly increased use of films in the fields of government, education, television and industry, it is often desirable to have available alternate sound versions of certain productions in order to serve the widest possible audience.

Typical applications of these versions are:

(a) For distribution in foreign countries.

(b) For presentation to audiences of different intellectual interests and training. For example, a drug firm may wish to present one technical version of a treatment to a medical audience and, using the same visuals, also present a lay audience version.

(c) For television presentation it may be necessary to present a film minus the music track because of trade regulations.

Because of these and other potential needs it is now common practice for many film production units to record, in addition to the original language version of the film, a separate music and effects track and a voice and effects track. The music and effects track may be used for foreign or other English language dubbing and the voice and effects track may be used for television prints where restrictions on the musical score are in effect.

The details of preparing an alternate sound version of a completed production vary somewhat in different studios, but in general they follow this pattern.

First consideration must be given to the economic factors of distribution which in turn will indicate the most desirable method of presenting the new sound treatment of the film to the public. With an eye to the budget, the producer and distributor will probably discuss these techniques:

Presented on April 25, 1952, at the Society's Convention at Chicago, Ill., by C. E. Beachell and G. G. Graham, National Film Board of Canada, John St., Ottawa, Ontario, Canada.

(a) The sound volume on the projector may be turned down and a commentary may then be supplied by the operator. This method is often used in schools with reasonable effectiveness but in the hands of an inexperienced person the results can be disastrous.

(b) Subtitles may be added to existing prints, which have completed domestic distribution, by means of an etching process. If additional prints are required, subtitles may be printed from mattes. Choice of either of these methods depends upon the volume of prints required.

(c) For prestige purposes and/or commercial distribution completely new sound tracks may be prepared which will permit the film to be presented as a standard composite print. Current developments in magnetic striping of existing and new prints suggests a further method of presenting this type of version.

Perhaps it is in order to discuss methods (b) and (c) more fully.

Etched Subtitles

In this process, subtitles giving the essential text required to explain the action of the visuals are added to the lower one-third to one-quarter of several frames of each scene by means of these steps:

(a) The print embossing plates which provide a relief image of the text type are made. One European process permits direct typing on the film and thus obviates the need of individual type plates.

(b) The print to be subtitled is coated with a bleach-resistant material such as paraffin wax.

(c) At the desired places throughout each reel the printing plate is hot-pressed on the coated film so that the type image penetrates to the emulsion surface.

(d) The film is then run through a bleach and clearing bath during which the image in the type areas is completely removed.

(e) The wax coating is removed with suitable solvent and the subtitles appear on the completed print as white letters.

Matte Printed Subtitles

In this process a text similar to that described above is applied during the release printing operations as follows:

(a) Individual title cards bearing the text for each scene are prepared and shot on the animation stand. If more than one set of mattes is required, black letters on a white background may be used to provide a printing negative.

(b) The negative titles are now printed on positive stock to provide black letters against a clear base.

(c) The subtitle printing matte is synchronized with the release printing picture negative and both of these films are run through the printer in contact with the positive raw stock. The text appears as white letters against the picture background.

This is a deliberate simplification of the preceding process which involves much more consideration of negative and positive print densities in the subtitle areas than is indicated here.

Dubbing

Most of the foreign language dubbing is presently done in Europe where considerable skills in translating and recording lip-synchronized dialogue have been developed over many years. The advantages of this arrangement are:

(a) Translations may be obtained which contain the current idioms of the area in question and which avoid offensive reference to controversial questions involving the national, political or religious beliefs of the country concerned.

(b) A relatively large number of translators and actors are available who have a detailed knowledge of the English language and who are trained to inject the proper feeling and authenticity into the characterizations.

(c) Most distributing firms have funds frozen in various foreign countries and

this fact, coupled with restrictions on the import of prints from hard-currency areas, makes this method of operation desirable from an economic standpoint.

Recent developments of magnetic striping, such as those described at this Society's conventions and in the *Journal*, have opened up further possibilities for the application of alternate sound tracks to existing prints. The high quality of reproduction obtained with this system along with the simplicity of operation should permit its use in the foreign or alternate English version field in a most practical manner.

Obviously the application of a foreign or alternate English language track to a commentary-type film is a reasonably simple operation. It becomes quite complicated, however, when the sound must be supplied as dialogue to match the lip synchronism of the visuals. Special techniques for analyzing the voice portions of the original track and selecting words in the new version which match the phrasing and inflections of the original have been developed by De Lane Lee and others in Europe. Individual scene loops are recorded on magnetic stock in an erase-record cycle until a desirable take is secured. The individual sequences are later mixed with the music and effects track (which has been recorded previously) to provide the completed track. Usually new titles are prepared for release printing versions of this type and with these cut into the printing dupe and synchronized with the sound track the film is ready for release printing. Although this latter method requires the making of a new sound track, it is presently considered to be the most effective way of presenting a supplementary version of a film. The methods and techniques to be discussed in this paper deal with the application and utilization of such alternate sound tracks.

The National Film Board of Canada is faced with the continuing problem of producing films in both the French and English languages for its domestic distribution. In addition to this, the prospect of increased coverage in Europe to assist the Canadian government's immigration program as well as greater activity in the fields of education and television led to study of methods to provide greater flexibility in the utilization of 16mm and 35mm prints.

The use of subtitles was considered and abandoned for these reasons:

(a) It is extremely difficult to present sufficient text within the space allotted in documentary films where the commentary is not necessarily linked to the visuals in an obvious manner as is the case in a story-line type of film.

(b) The attention of the spectator must be divided between the picture image and text, and consequently the ability to understand the film is reduced.

(c) In many areas of the world it is desirable to show the films to illiterate audiences which, of course, reduces the effectiveness of this method.

Magnetic striping provides an acceptable quality sound track and is ideal in certain circumstances. Its principal disadvantages at this time appear to be:

(a) The cost of new projectors or converting existing projectors is quite high. This is particularly significant in areas where several hundred projectors are in use.

(b) The cost of striping a print and transferring the new sound track adds considerably to the sale price of the print.

(c) The fact that the sound track can be erased and replaced with an entirely different track without reference to the original producer could have serious consequences. By design or accident, interpretation of the visuals could be used indiscriminately to express opinions which would cause embarrassment to the organization or country responsible for production and distribution of the film.

As a result of these conclusions and to meet the needs of other agencies of

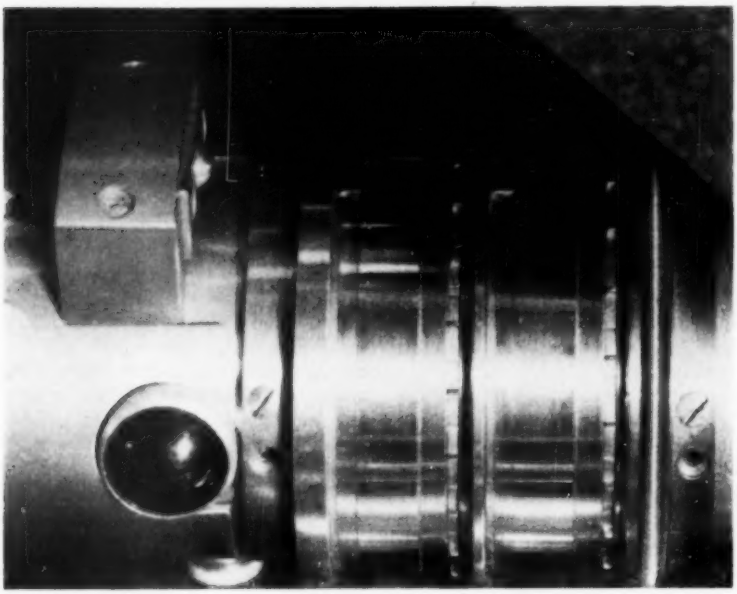


Fig. 1. Close-up of Debrie Sound Adaptor, showing sound aperture masks in position.

Fig. 2. Normal track provided by Maurer Sound Recorder.

government concerned with film distribution the following objectives were established:

(a) The overall quality of the sound should not be impaired.

(b) The technique devised must be applicable to existing films as well as those to be produced in the future.

(c) In view of the capital investment in projectors, any method of changing the character of the sound track must be accomplished through adaptation of available equipment. It was, of course, mandatory that any conversion unit applied to the projector must not, in any way, prohibit its use for projection of standard films.

(d) The technique developed should insure an appreciable saving in print costs to the distributor and consumer.

(e) The sound track supplied should be that prepared by the producer of the film and should remain a permanent part of the print itself.

In view of the success achieved in reproduction of the 50-mil optical track portion of the striped magnetic sound systems, it was decided to concentrate on producing a double optical sound image each portion of which would be 50 mils in width. Either of these tracks could then be reproduced at will by simply inserting a suitable mask in the sound scanning beam of a 16mm projector.

In preparing these dual-purpose sound prints it was found that two methods could be used. With the use of half-width masks alternately on opposite sides of the sound aperture and a double printing operation, the prints may be made from existing sound negatives by the processing laboratory. To avoid the double-printing operation, a similar masking technique may be used on an optical recorder. In this case two separate recordings are made in the standard single-track area on an interlock system by exposing one side, then reversing the mask, rewinding the stock and exposing the second half.

Adaptation of Printers

For the preliminary experimental work a double sound head Debrie Matipo printer was used. The alternate halves of each sound aperture were masked with brass shim stock suitably blackened to reduce reflection (Fig. 1). The Matipo printer is particularly suitable for this work since the sound gate is slightly undercut from the film path. Consequently a mask may be inserted in such a manner that it clears the moving film by about 0.010 in.

To adjust the mask a standard negative is placed in its normal position on the aperture. Over this a piece of positive raw stock is placed so that the image of the track and the mask impinges on it when illuminated by the printer lamp. With the use of a toolmaker's microscope, the mask is moved to split the track at the 50-mil position. Fine centering of the mask image on the positive stock is accomplished by adjustment of the printer-lamp position. Figure 2 shows a section of multiple bilateral track from a Maurer recorder. The track is split in printing half-way between sections 3 and 4.

Two samples of tracks printed and recorded in this manner are shown in Figs. 3 and 4. Figure 3 shows the result of mask overlap of approximately 0.010 in. which causes a loss of two tracks. Figure 4 illustrates a finer adjustment of the masks to eliminate the unexposed center strip completely.

When it was established that the unexposed center area could be eliminated, an alternate use of this technique suggested itself. Instead of putting entirely different sound tracks on each 50-mil portion, it might now be possible to print or record different portions of the same track on each half-track portion. To check this reasoning a special mix of a sound track was prepared. The tracks to be mixed consisted of two music, and four voice and effects reels. From the dubbers the sound was fed

Fig. 3. First track split, showing effect of mask overlap.

Fig. 4. Second track split, with masks adjusted to eliminate overlap.

as shown in Fig. 5. The mixer heard the combined effect of all tracks over his monitor speakers, but at the recording stage the signals were bridged so that the music was recorded on an interlocked magnetic recorder while the voice and effects were picked up on a masked optical system. The magnetic track was transferred to the opposite half of the optical negative and the combined tracks were printed onto the positive stock. When played on a standard projector the full track is reproduced, while on an adapted projector the print may be played as full sound, voice and effects, or music only. This type of print appears to offer certain advantages:

(a) On full-track reproduction, since

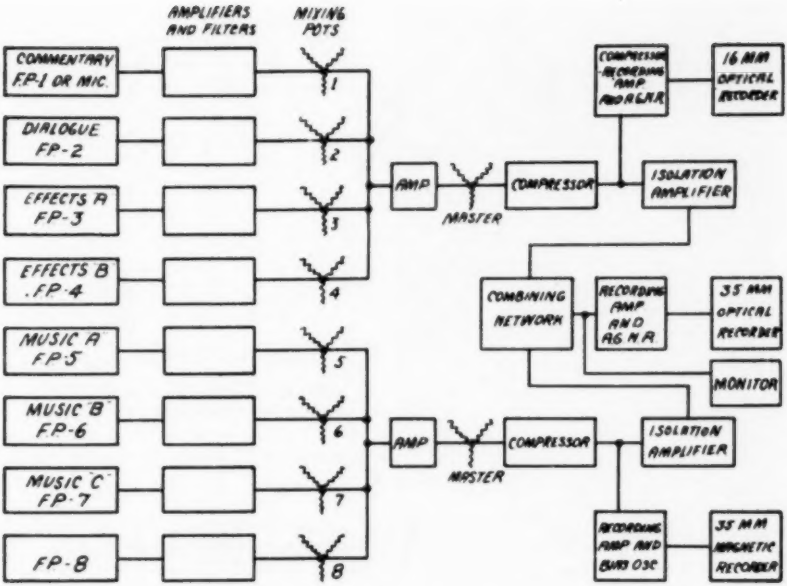


Fig. 5. Diagram of divided track re-recording system.

the high- and low-frequency components are physically separated, intermodulation distortion effect in the recording and printing stages is greatly reduced.

(b) The music portion only of the track may be reproduced when, for example, the print is used for educational purposes and the teacher wishes to supply his or her own commentary. Alternatively, many teachers feel that music detracts from the effectiveness of an education subject and in such cases the voice and effects portion alone may be used.

(c) A third possible application lies in the television field. Split-track prints may be distributed generally for reproduction on standard projectors. However, the same print may be rented or sold to television stations which in turn may reproduce only the voice and effects portion. This eliminates the need for special prints of sound negatives where trade regulations prohibit the reproduction of film music on television networks.

Mechanical Adaptation of Recorders

Figure 6 shows plan views of the RCA and Western Electric optical paths. Suitable half-track masks could be installed at the points shown. In the Maurer recorder the mask is introduced at the ultraviolet filter holder position so that its image is produced sharply on the film in the desired position. During the early experiments masks were used at the film plane for reasons of convenience. However, the points noted in Fig. 6 would permit a more precise arrangement for continuous use.

Split-track recording may be used for two purposes:

(a) To divide the contents of a single track into two portions: i.e., music, and voice and effects; or music and effects, and voice.

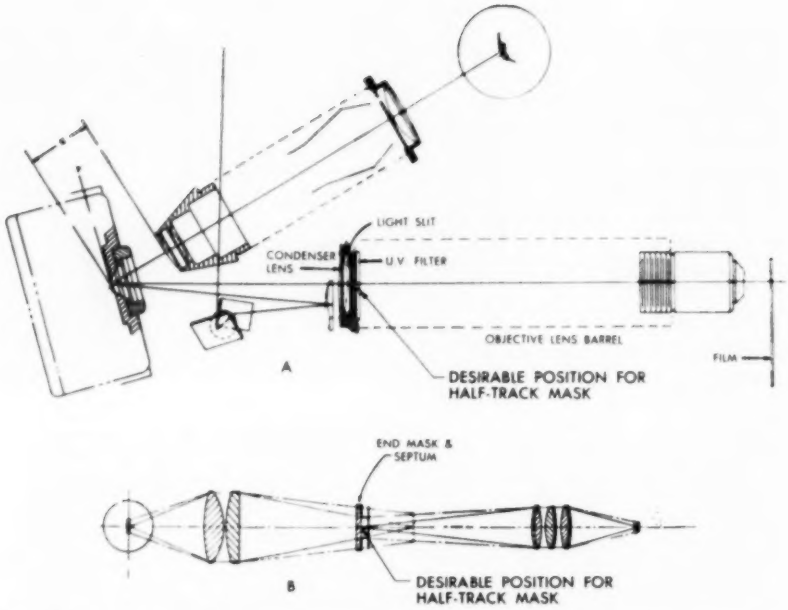


Fig. 6. (A) RCA Optical System, plan view; (B) Westrex Optical System, plan view.

(b) To place within the single-track area of a standard 35mm or 16mm negative two separate sound versions: i.e., English and French tracks, two English tracks, etc.

Where separate language versions are required, the originals are recorded separately in the regular manner on 35mm magnetic stock. These tracks may then be transferred to the masked recorder as described above.

The particular advantages of double-track sound negatives are:

(a) The laboratory printing step is reduced to a standard single operation and consequently two print versions may be produced for the price of one.

(b) Any overlap of the masks on the sound negative record is reproduced as a continuous black unmodulated line on the print. This is preferable to the white line left by overlapping of the masks on the release printer since this would raise the noise level when reproduced on full-width scanning.

(c) On a recorder greater accuracy of center-line placement can be assured and the danger of clipping is reduced. In addition, negative recording stock is usually in good physical condition so that no compensation for shrinkage need be applied.

Projector Conversion

The prototype model shown here (Fig. 7) is a very simple adaptor which may be fitted to most 16mm projectors. The pivoted mask is U-shaped, with adjusting screws for proper horizontal positioning of the projector sound scanning beam. Since the vertical dimension of the scanning beam is defined by the optical system of the projector, no provision need be made for this on the adaptor. This fortunate circumstance greatly reduces the manu-

facturing cost of the unit. With this adaptor the sound track may be reproduced as full-width normal. 50-mil left and 50-mil right. The actual width of the scanned area is slightly under 50 mils to avoid picking up unwanted signal due to weave in the film path or miscentering due to shrinkage. Further fine adjustment may be made by means of the adjusting screws if necessary.

The mask is suitably curved so that it will not cut into the film in the event of a break or when the end is passing through.

Using either half of the split track, the sound quality is quite acceptable. For experimental purposes an old Bell & Howell No. 179 projector (Fig. 8) was selected as representative of a type still

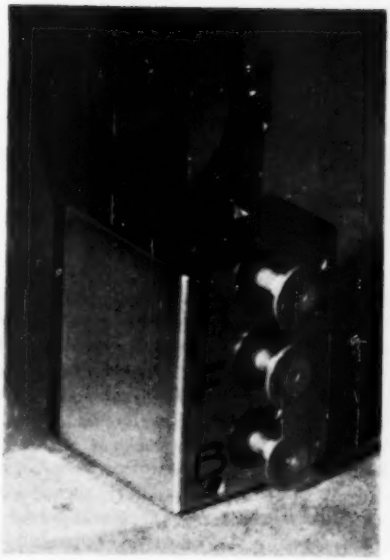
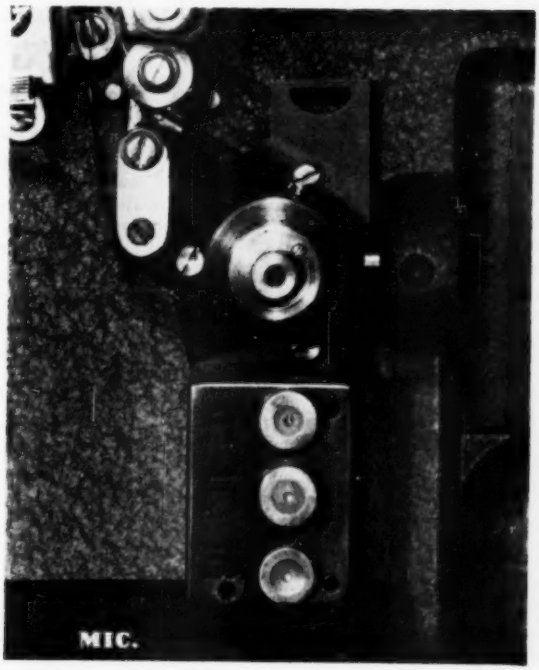


Fig. 7. 16-mm projector adaptor.

Fig. 8. Adaptor in position on Bell & Howell, Model 179.



used extensively in Canada. With the amplifier in good working condition and the sound scanning beam balanced to $\pm 1\frac{1}{2}$ db across its full width, the sound level of the half-track is down approximately 5 to 6 db. The frequency response characteristic remains unchanged. Signal-to-noise ratio of the projector is not affected since the scanning beam is mechanically reduced by one-half. There is an increase of amplifier noise since the gain must be increased to compensate for the volume loss on the half-track. However, this is not serious for all normal requirements.

While this system is particularly adaptable to variable density and multiple bilateral area tracks it is also applicable to other types of area tracks with the exception of unilateral records.

In conclusion this 50-mil optical track system appears to offer the following advantages which are applicable to either 35mm or 16mm black-and-white or color film prints:

(a) Double- and possibly triple-version tracks may be produced on a single print at very low cost, thus introducing economy for film users in various fields.

(b) Using the split tracks for independent recording of the low- and high-frequency components of a single sound track will reduce intermodulation distortion. By means of selective playback, greater utilization of the same print may be made.

(c) The cost of adapting a projector for this purpose will probably be less than fifteen dollars per machine and the adaptor will not, in any way, limit the projector for use with regular films.

Discussion

John G. Frayne: I would like to offer a suggestion if I may to Mr. Graham. It's possible with the valve which I believe you showed in that slide, the RA-1238 push-pull valve, to reconnect it so that you can record two independent tracks simultaneously. Have you tried that?

Gerald G. Graham: No, not yet.

Dr. Frayne: It can be done very easily.

Mr. Graham: It's an excellent suggestion.

Dr. Frayne: You merely put the two separate signals on the two outside noise-reduction ribbons, superimpose the noise-reduction currents on these and keep the center ribbon as a mask. You thus get two independent tracks. In the case of variable area, you simply connect each ribbon to an independent signal and noise-reduction input and thus obtain two separate VA tracks.

Mr. Graham: Yes, to date in the experimental work we haven't actually been delving into the recording system. We've tried to work outside of that. That is something we would like to do next.

H. R. Kossman: The speaker mentions making superimposed titles. However, there is another method — it's a Debrie printer which accomplishes this by projecting one single text frame onto the negative while the printer runs. This means a considerable saving in matte costs.

Theory of Parallax Barriers

By SAM H. KAPLAN

The parallax barrier, which is a type of selective masking device now being applied in color television and in stereoscopic imagery, is discussed. A brief history along with the principle and geometric relationship underlying its operation is given. Various systems employing two or more image elements per aperture and utilizing the maximum image area are described. It is also shown that nonplanar and nonparallel arrangements are possible, and that plane barrier surfaces may be coupled to nonplanar image surfaces. Furthermore, lenses may replace the mechanical-type barriers resulting in a more light-efficient system. Formulae are presented and specific applications to multiple-color television tubes are discussed.

A PARALLAX BARRIER may be defined as a masking device which, when interposed between an object space and an image space, prevents any given part of the image space from being sighted from any but a given set of predetermined directions. Since both light and electron beams travel along straight paths, the laws of geometric optics apply irrespective of direction of travel along this path. Consequently, parallax barriers can be utilized where a viewing screen is observed from predetermined directions as in stereoscopic imagery, or where a luminescent screen is impinged upon by electron beams coming from specified directions, as in color television tubes. Parallax barriers are now being used for both of these purposes.

Presented on April 21, 1952, at the Society's Convention at Chicago, Ill., by Sam H. Kaplan, Consultant, 3713 W. Arthington, Chicago 24, Ill.

Brief History

The concept of the parallax barrier is generally attributed to Berthier[1] of France who suggested it in 1896. However it was first applied by Frederick E. Ives[1] to produce stereoscopic still pictures in 1904. These were called "parallax stereograms" and required no separate viewing accessories. The substitution of lenses as an alternate to mechanical blocking barriers was proposed by Gabriel Lippman of France in 1908.[2] A barrier system with more than two elements behind each barrier aperture was invented by C. W. Kanolt who obtained U.S. Patent 1,260,682 on March 26, 1918. His stereoscopic pictures were called "parallax panoramagrams" and revealed a multitude of stereoscopic views as the picture was viewed from different angles. A radial nonparallel-type barrier system was invented by B. T. Ivanof[3] who first

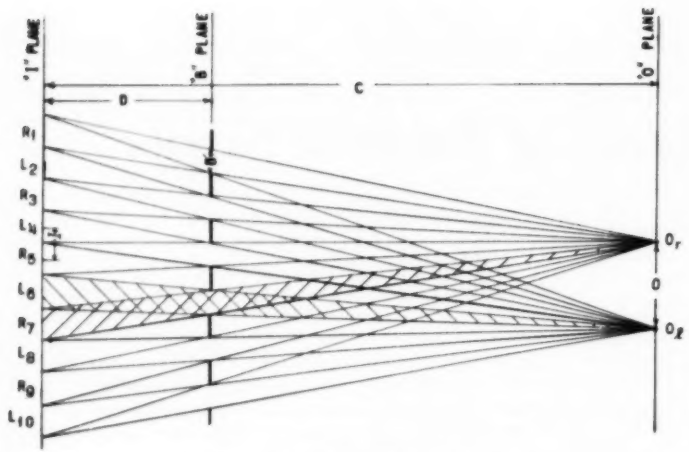


Fig. 1. Two-element barrier.

used it in 1941 to show projected stereoscopic motion pictures in Russia.

The use of parallax barriers as external attachments to cathode-ray tubes for stereoscopic television is included in several patents. The use of such parallax barriers *inside* a cathode-ray tube, as a positive means of insuring that portions of a mosaic screen would be subjected to bombardment only by a predetermined electron beam, was first revealed in German Patent 736,575, issued June 22, 1943. The application date is July 12, 1938, and the inventor was Dr. Warner Fleshig of Fernseh A.G.

Principle and Geometric Relationships

The application of the parallax barrier to stereoscopic pictures can serve to illustrate the principle (see Fig. 1). Two pictures taken from slightly separated points of view and designated as left and right views, are divided into fine strips and reassembled on an alternate basis: R_1, L_2, R_3, L_4, R_5, etc., (the odd numbered L strips and the even numbered R strips are not used). In front of the reassembled picture (labeled "I" plane) there is placed a series of opaque strip barriers separated by transparent strips of equal width (labeled "B" plane). If the barrier is properly located between the picture and the viewer's eyes (labeled O_l and O_r), the left eye will see only the strips L_2, L_4, L_6, etc., (the R strips being hidden by the barriers). Likewise, the right eye will see only strips R_1, R_3, R_5, etc. If the strips are of such small width that they are not individually resolved by the eye, a stereoscopic picture results, since each eye sees only the picture corresponding to its field of view.

From simple geometrical considerations it is possible to determine that the relationship between image distance (D), distance between image strip centers (I), separation of eyes (O), and distance of eye plane to image plane (C), is:

$$D = \frac{IC}{O + I} \qquad (1)$$

Although the distance between the eyes (labeled as "O" points) and the image increases steadily in going from the center to the edges of the image, the bandwidth of the picture strips and barrier strips is constant and is independent of the angle between any image

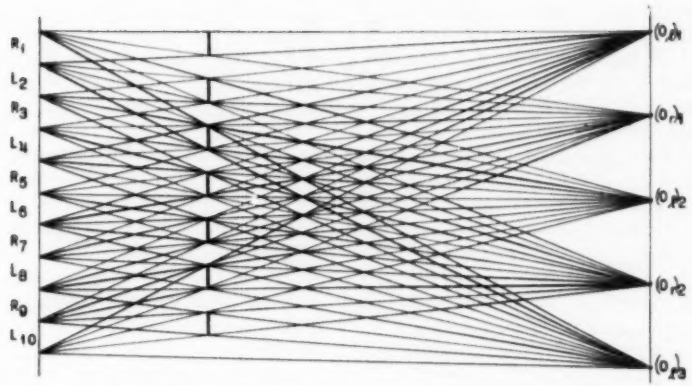


Fig. 2. Two-element barrier showing repeating "O" points.

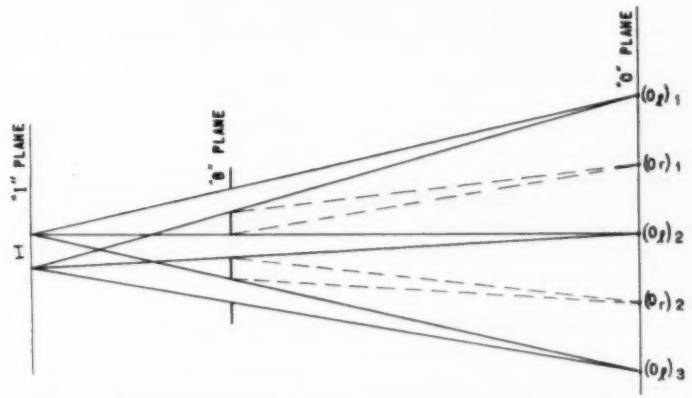


Fig. 3. Alternate viewing of same element by different "O" points.

portion and the line of viewing. Proof is given in an article by C. S. Szegho.[4] The width (B′) separating the barrier strips can be determined from similar triangles to be:

$$B' = \left(\frac{C - D}{C}\right) I \qquad (2)$$

In this case the distance B between barrier strip centers is 2B′.

The question arises whether there are other points in addition to O_l and O_r from which the same picture (i.e., left image seen by left eye and right image seen by right eye) can be viewed. As shown in Fig. 2, by projecting rays from the image through the apertures between barriers, using in turn different barrier spaces for a given image strip, one can obtain an alternating sequence of equally spaced O_l and O_r points. Any combination of O_l and O_r points, whether adjacent or nonadjacent, will fulfill the condition that one "O" point "sees" only one image set and the second "O" point sees the alternate image set. Figure 3 shows in more detail the relationship between these

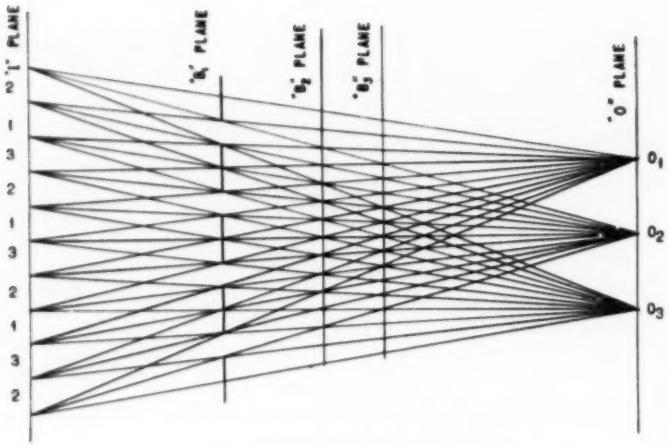


Fig. 4. Three-element barrier system;
second- and third-order barrier planes shown.

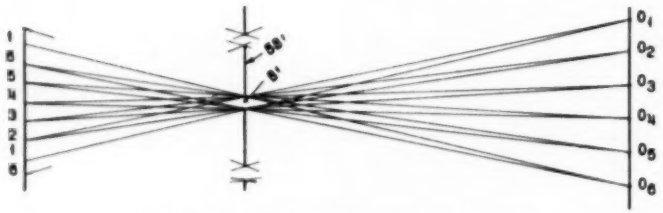


Fig. 5. One cycle of a six-element system.

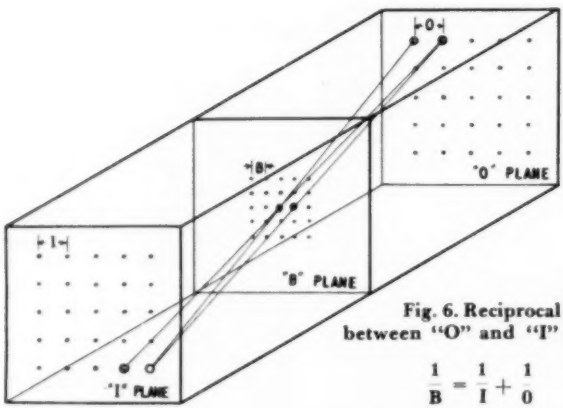


Fig. 6. Reciprocal relation
between "O" and "I" planes;

$$\frac{1}{B} = \frac{1}{I} + \frac{1}{O}$$

different "O" points and a given image strip. The only difference is that a particular strip (in this case L_1) is "seen" by $(O_1)_1$, by $(O_1)_2$, and by $(O_1)_3$ through different barrier plane apertures.

Barriers for More Than Two Image Elements per Aperture

Instead of two viewing points (called "O" points) coupled to two mutually intermeshed image area sets, three or more intermeshed image area sets can be coupled to a corresponding number of viewing points. Such an arrangement is possible if the barrier has a ratio of aperture area to total barrier plane of $1/N$ or less, where N equals the number of points coupled to a similar number of sets of mutually exclusive area elements. For a three-element arrangement the width of the barrier member must be at least twice that of the aperture width; for a four-element arrangement the barrier width is at least three times the aperture width. A three-element arrangement is shown in Fig. 4. One section of a six-element arrangement is shown in Fig. 5.

While the "O" plane has been considered up to this point as a viewing plane, the various "O" points in the "O" plane may also be considered as origins of electrons or other radiation, for the purpose of creating a parallax system consisting of an image plane, a barrier plane and an origin (or object) plane.

In order to generalize the theory of parallax barriers, consider the barrier plane to be covered with a regular repeating dot pattern (such as the rectangular dot pattern shown in Fig. 6). If there is a point source of rays in the O plane, the pattern in the barrier plane will be projected on the image plane I and will be enlarged in the ratio of $\left(\frac{C}{C-D}\right)$. If any particular point in the above projected image plane I is considered as an origin, then it will project the barrier plane pattern onto the O plane and the pattern will be enlarged in the ratio of C/D. Any dot in the resulting O plane pattern can be shown to be in the correct position for projection of the barrier pattern onto the previously projected I plane pattern. The different dots in the O plane can be considered to correspond to the $(O_1)_1$, $(O_1)_2$, $(O_1)_3$ points of Fig. 3. Thus we see that the patterns of image and origin planes bear reciprocal relationship to each other, and the functions of O and I may be interchanged. Mathematically:

$$\frac{1}{B} = \frac{1}{O} + \frac{1}{I} \qquad (3)$$

where B, O and I are the pattern sizes in the B, O and I planes, respectively. The dots of these patterns serve as the centers for the area patterns actually used. Desirable area shapes and pattern arrangements are discussed below.

To develop a two-element, a three-element or an N-element arrangement, it is necessary to intermesh two, three or N patterns in both the image and origin planes between each other. Each image pattern is then coupled to a corresponding mutually exclusive origin pattern. Figure 7 illustrates a two- and three-element arrangement.

Arrangements of Image Elements

Practical considerations call for the maximum utilization of available area in the image plane. Although many geometrical patterns exist which can cover an entire area, only a few meet the two following criteria:

(1) The patterns must contain only the same shape and size elements.

(2) All the elements must have the same orientation.

Arrangements meeting these criteria are parallelograms (including rectangles and squares) and hexagons. Although an area may be covered by isosceles triangles, such an arrangement does not fulfill the second criterion since

Fig. 7a. Two intermeshed patterns.

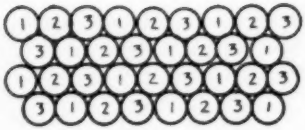


Fig. 7b. Three intermeshed patterns; circle area elements also shown.

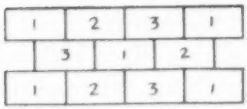


Fig. 8a. Rectangular three-element pattern.

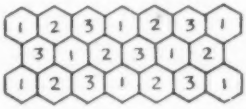


Fig. 8b. Hexagonal three-element pattern.

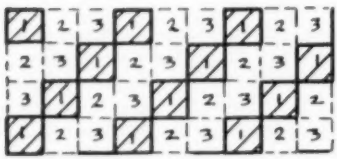


Fig. 9a. Open barrier arrangements, staggered.

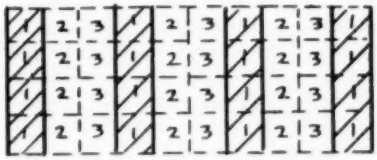


Fig. 9b. Open barrier arrangements, nonstaggered (bands).

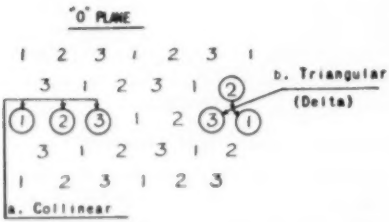


Fig. 10. Preferred three-element origin arrangements.

half the triangles have one orientation and half are oriented 180° out of phase with the first set. From a practical point of view, ellipses (including circles) may be considered to fulfill the necessary conditions, although only 90.7% of the available area is covered when these are in the close-packed arrangement shown in Fig. 7b.

Classification of Barriers

Closed- and Open-Barrier Structures. It is possible to classify parallax barriers with respect to aperture boundaries. The apertures can either meet or not, and the barriers can then be called "open" or "closed," respectively. In the closed-structure type, each aperture is completely surrounded by barrier. Open-barrier structures consist of bands, either straight or staggered.

Three-element arrangements can utilize either open- or closed-type barriers. In order to transform open barriers to the closed-barrier type, alternate image row areas must be staggered 180° with reference to the preceding row. Figure 8 illustrates the image plane arrangement for rectangles and hexagons to go with a closed-type barrier. See Fig. 7b for a similar arrangement for circles. Where rec-

tangles are used and the elements are under one another, only an open-barrier band-type arrangement is possible (shown in Fig. 9).

In the three-element arrangement one origin point is usually selected from each of the three intermeshed O plane patterns. For most purposes it is desirable to choose the O points as close together as possible. The three points may be selected from three adjacent O points in a single line, leading to a "collinear" arrangement shown in Fig. 10a, or the O points may be selected to constitute the apices of a triangle — a "delta" arrangement — leading to an even closer pattern, as shown in Fig. 10b.

Higher Order Barriers. The barriers already described have a reciprocal arrangement between image, source and barrier pattern centers. By looking again at Fig. 4, one may see that there are other possible barrier locations (formed by ray intersections) which fulfill the basic condition of having each image area "seen" by only one of the O points. These locations are shown on the drawing as B_2, B_3, etc. and correspond to the selection of nonadjacent O points from a smaller submultiple O plane pattern. The first barrier plane shown has the O points taken from adjacent points of a pattern having a separation of distance O. The second barrier plane corresponds to the selection of alternate points of a pattern having points separated by distance $\frac{1}{2}$O. The third plane corresponds to the selection of every third point of a pattern with point separation of $\frac{1}{3}$O. This third barrier plane cannot be used in a three-element arrangement since it means all three O points have been taken from the same point set in the O plane, instead of having one O point taken from each of the three intermeshed sets. Each O point would "see" the same image set, and the other two image area sets would be seen by none of the O points. The formula for these other image-to-barrier-plane spacings is given as:

$$D = \frac{KIC}{O + KI} \qquad (4)$$

where K is the ratio of O distance to the smallest O pattern spacing. When using these higher order barriers, the elements of a given image cluster are "seen" by the O points through different apertures, instead of through a single aperture as is the case for the first barrier plane.

Nonplanar Barriers and Images. The parallax barrier principle is not limited to three parallel planes. Consider a spherical surface I and two O points, as shown in Fig. 11a. The locus of the intersections of pairs of rays which are a fixed distance apart on the image surface and pass through the two given O points will sweep out a curve which meets the parallax criteria. This surface will not be a sphere. In this case the size of the elements on the image surface is uniform. By sacrificing this condition, any given barrier B and image I surfaces can be arbitrarily chosen to meet the parallax condition for any given O points. For example, in Fig. 11b, curve I can be a circle (in three dimensions spherical) and curve B may be a plane or a sphere with any given radius. The patterns on I and B must be constructed by a point-by-point method. An example of a two-element construction is illustrated in Fig. 11a. Starting with line 1 connecting O_2 and I_1, draw line 2 connecting O_1 and B_1 (the point of intersection of line 1 and curve B), continuing on to curve I. Line 3 then connects O_2 and I_2 (the point of intersection of line 2 and I). Line 4 connects O_1 and B_2 (the point of intersection of line 3 with B), etc. In other words, O_2 lines connect with previous intersection points on I and O_1 lines connect with previous intersection points on B. The examples are shown in two dimensions. The three-

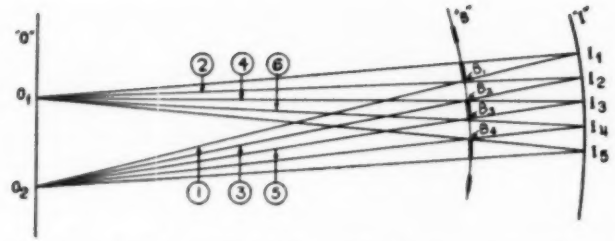


Fig. 11a. Construction of spherical "I" and "B" surfaces, nonuniform elements.

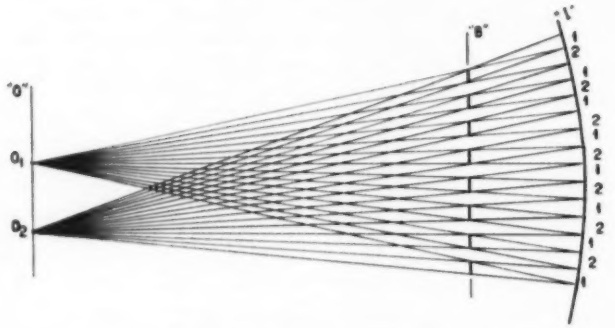


Fig. 11b. Spherical "I" and plane "B" surfaces.

dimension arrangement necessary for any practical use is more complicated.

The above analysis is based upon a 100% utilization of available image area. It may be desirable to have both fixed surfaces of given shapes and a uniform pattern on one of the surfaces. This can be done, but only by sacrificing some of the image area. For example, the surface I can be chosen as spherical, and the barrier surface as a plane with a uniform dot pattern. This can be done if the aperture size in the plane barrier is small enough to avoid overlapping patterns on surface I.

The Radial-Type Barrier. If the image, barrier and source surfaces are planar, they need not be parallel. The above principles can be used to generate nonparallel arrangements. One such arrangement of interest is the radial plane arrangement, invented by Ivanof and used for stereoscopic pictures. As shown in Fig. 12, all three planes meet in a common line of intersection and all band patterns of I, B and O planes converge toward a single point on this common line of intersection. For motion pictures—the I plane comprises the screen; the B plane, the parallax barrier; and the audience, the O plane. This arrangement permits a large number of seats to satisfy the parallax condition, in contrast to the parallel plane arrangement where only one row in the theater can meet the necessary condition. Of course, if the rows could be stacked vertically instead of horizontally then the parallel plane arrangement would be suitable.

The Venetian-Blind Barrier. Instead of a separate barrier plane, the surface itself can be shaped to provide the

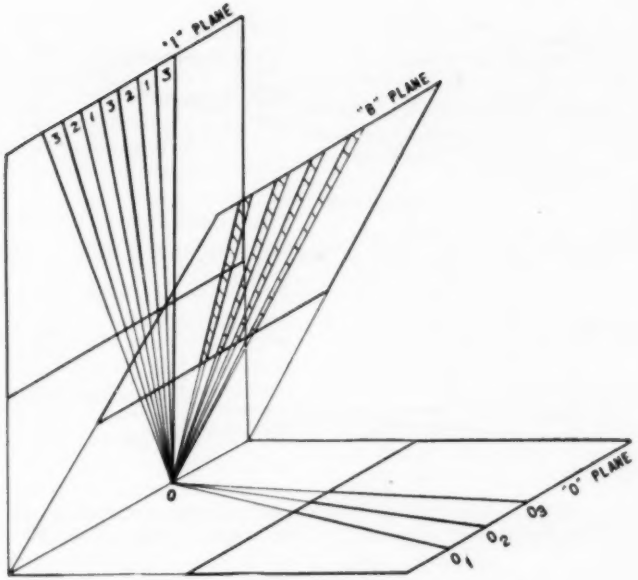


Fig. 12. The radial barrier arrangement.

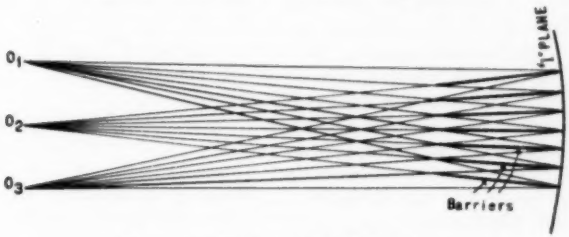


Fig. 13. Venetian-blind barrier.

necessary parallax condition as shown in Fig. 13. The sides of the slats form two of the three image areas. The surface now resembles a venetian blind. The height of the slats is equal to the distance D as in the other arrangements and is determined by the construction methods and formulae already given.

Physical Limitations and How to Minimize Them

Light Loss Caused by the Barrier. One defect in the practical application of parallax barriers is the transmission loss introduced by the barrier itself. This limitation can be minimized by replacing each aperture or slit by a spherical or a cylindrical lens, as shown in Fig. 14. Replacing the aperture by a larger size lens can theoretically cut the barrier loss to zero. Instead of acting as a mechanical barrier, the lenses refract or converge the rays to the proper position on the image surface. In stereoscopic picture processes modern practice calls for cylindrical lens elements

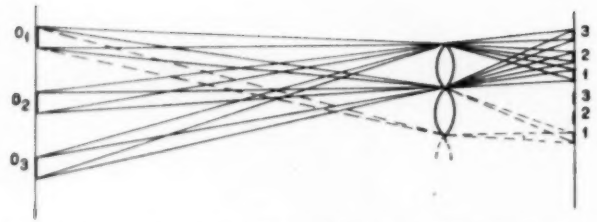


Fig. 14. Lens equivalent of barrier; finite "O" points shown.

Fig. 15. Effect of finite size of "O" to avoid overlapping; "I" must be reduced to "I′", or "B′" must be reduced to "B″."

molded into the film base. If one deals with electron rays instead of light, electron lenses can be used, and the apertures themselves can act as the electron lenses. Owing to the focusing action, these apertures, serving as electron lenses, can be larger, thus increasing the number of electrons reaching the image plane I. To make the apertures behave as electron lenses, it is only necessary to provide for an electric field between I and B greater than between B and O.

Finite-Area Sources. All previous discussion has been on the basis of point sources in the O plane. Actually, especially in electronic apparatus, the O points have appreciable area. In order to ensure that each O point sees only its own image plane patterns when using barriers (rather than lenses), it is necessary (see Fig. 15) to reduce either the size of the barrier plane apertures B′ or the size of the image plane elements I′, in either case maintaining the same separation distance between apertures and image elements. Figure 15 shows the proper geometrical solution to achieve the nonoverlapping condition of image areas. The reduced sizes are by similar triangles:

$$B'' = I\left(\frac{C - D}{C}\right) - \left(\frac{D}{C}\right)O' \qquad (5)$$

or

$$I' = I - \left(\frac{B'}{C - D}\right)O' \qquad (6)$$

where O′ is size of O area and B′ and I′ are the sizes of apertures and image elements, respectively. The reduced B″ or I′ size will result in loss of efficiency by reducing the number of rays from the O points which can be utilized.

Practical Application of Barriers in Cathode-Ray Tubes

The parallax barrier is particularly suitable as an internal member in cathode-ray tubes, permitting positive screen area control and ensuring that a given beam impinge only on a given portion of the fluorescent screen. Specified screen areas are associated with a desired source of electrons, and electrons from other sources are blocked from the

same area by the barrier. The control is effected by the real or apparent position of the electron source. Either a separate electron gun is used for each independent set of elements or the beam originating in a single electron gun may be successively shifted through the proper O points. Such cathode-ray tubes can be used in multitrace oscilloscopes giving each trace a different color, or as multicolor radarscope for differentiating by color such things as moving targets, radar beacons, etc. The most important application, however, appears to be for color television in two-, three- or four-color sequential or simultaneous-type systems. A large number of tricolor picture tubes are being built on this principle.[4,5,6] At present the application of the parallax barrier principle in a cathode-ray tube represents the most promising solution for an all-electronic color television viewing device.

Acknowledgments

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New Direct-Vision Stereo-Projection Screen

By W. WHEELER JENNINGS and PIERRE VANET

This paper discusses the development of a new direct-vision stereo-projection screen. It permits the audience to see three-dimensional color motion pictures and slides without the aid of conventional polarized viewing glasses.

FOR MORE THAN half a century, thousands of dollars have been invested by researchers in the hope of developing a good commercial free-vision stereo-projection screen. The problems encountered have been very complex.

First, let us re-examine the mechanism of our visual impressions. We see objects in relief because of the perception of each of our eyes of a point located in space and observed at different angles that correspond to the distance between the eyes (Fig. 1). The convergent action of our eyes enables us to estimate by exploration the various distances of different points located in space.

The image received on the retina of the right eye is not the same as received by the left eye. In order to get the impression of relief, it is necessary to project two views taken at different angles and to avail oneself of means that will enable each eye to see only the picture it should receive at the exclusion of the other.[1]

In order to get natural binocular vision under our existing stereo-projection processes, it is necessary for the spectator to wear special polarized or red and green viewing spectacles.

We will deal here only with the processes of stereo projection that give us directly and collectively three-dimensional screen images as seen with our natural vision.

The Noaillon Theory

In 1928, Professor Noaillon, of Brussels, Belgium, developed a selector system, made up of radial converging lines in the form of grills with very wide openings. This system consists of three reclining grills shaking or oscillating in their own plane around their meeting points, as shown in Fig. 2.

Figure 3 shows projection on screen E through this radial-lined network which determines the selective vision surfaces. Starting from the stereo-projector G and D, representing the left and right stereo images, the projected image travels to the meeting point O

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by W. Wheeler Jennings, 7549 South Clyde Ave., Chicago 49, Ill., and Pierre Vanet, Societe des Anciens Etablissements, A. Mattey, Paris, France.

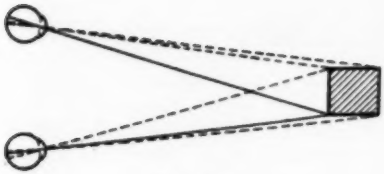
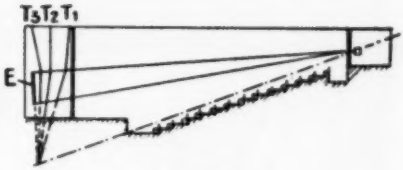


Figure 1.



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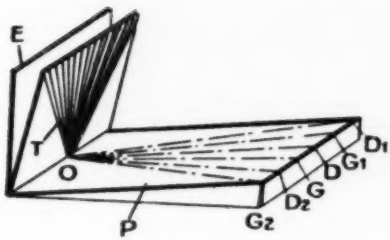

Figure 3.

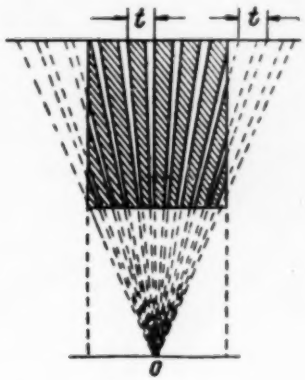

Figure 4.

of all the lines T of the converging grills. Direct-vision zones G2, D2, G1 and D1 radiate on surface P. The convergent setting of the selector grills brought an important improvement in the projected stereoscopic vision of depth.[2]

The Findings of Russia's Ivanov

In 1945 and 1946, we had newspaper reports of excellent 35mm stereo motion pictures and free-vision theater projection in Moscow. Much of the information sounded far-fetched, especially concerning the technical means employed.

Since that date, a translation from the Russian reveals most of the steps used in their process: The screen employed was of lined network design converging, similar to the Noaillon theory shown in Fig. 2 and 3, but Ivanov's network is stationary. This weblike network shown in Fig. 4 consists of more than 30,000 white enameled wires stretched from the top of the screen T to the meeting point on the bottom O. The shaded portion is the projected picture area. These wires pull a total tension of 30 tons. The total weight of the screen is approximately 6 tons. Figure 5 is a schematic of Russian origin showing the vertical screen format of the split frame. The stereo-screen image is estimated to be approximately 12 ft × 9 ft. Because of the very narrow and limited vision zones, the theater in which this screen is installed seats only 250 people.

According to Ivanov, the theory of Noaillon brought out the following defects: (1) considerable absorption of light and (2) a very narrow observation zone, which does not allow the spectator to move his head. These are

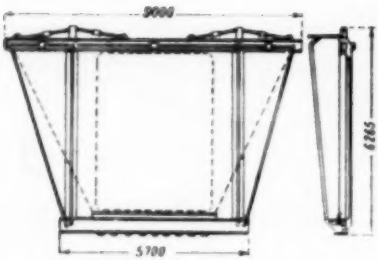

Figure 5.

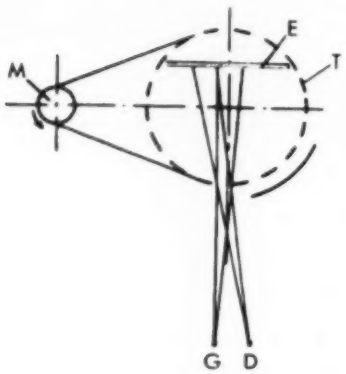

Figure 6.

all faults common to methods using the fixed stretched network screen.

In an attempt to remedy these faults, the Russians sought to achieve a selector system consisting of conical converging diopters. Unable to achieve the diopters mechanically by means used in optics, they tried to obtain the results by photographic means, probably by utilizing the properties of bichromate on the film emulsion, which permits an apparent relief.

Nevertheless, the Russians have made a careful study of the momentous problems of stereoscopic motion pictures, but they have struck a technical impossibility in realizing a suitable selector of transmission that does not produce the faults of light absorption and diffraction already discussed.

We have discussed the principal obstacles stopping the use of lined networks so that you will know of the difficulties of direct-vision stereoscopic projection.

Noaillon proposed to solve the problems by utilizing oscillating grills starting with a selector system with much larger openings between grills, which simplifies the construction of the stereoscopic network.

A New Direct-Vision Stereo-Projection Screen

Francois Savoye, member of the Commission of Color and Relief of the French National Cinema Centre, solved some of these problems in the design of this new free-vision screen.

This system is based on the properties of stereo-selection given by a rotating conical shaped grill T as shown in Figs. 6 and 8, moving around the surface of the screen E. This is part of the Noaillon theory with formation of converging zones, on the plane perpendicular to the plane on the screen. This device enables the collective direct-vision of stereoscopic pairs.[3] The impressions of relief are obtained in the same manner as by natural vision. Each spectator sees the right picture D for the right eye and the left picture G for the left eye. The rotating grill driven by motor M produces total shading, by persistence of vision sweeping the screen, thus showing the whole picture with all its detail in color or black-and-white.

Figure 7 shows a 5-ft screen with a projected stereo-image. This was photographed with a stereo-camera from the spectator's seat.

For the sake of simplicity, we will describe the engineer's model. The revolving grill in Fig. 8 is constructed of 108 aluminum bars forming the conical section. The top support of the cone is 36 in. in diameter. This accommodates a beaded screen 18 in. × 24 in. Each bar is set on geometric lines at

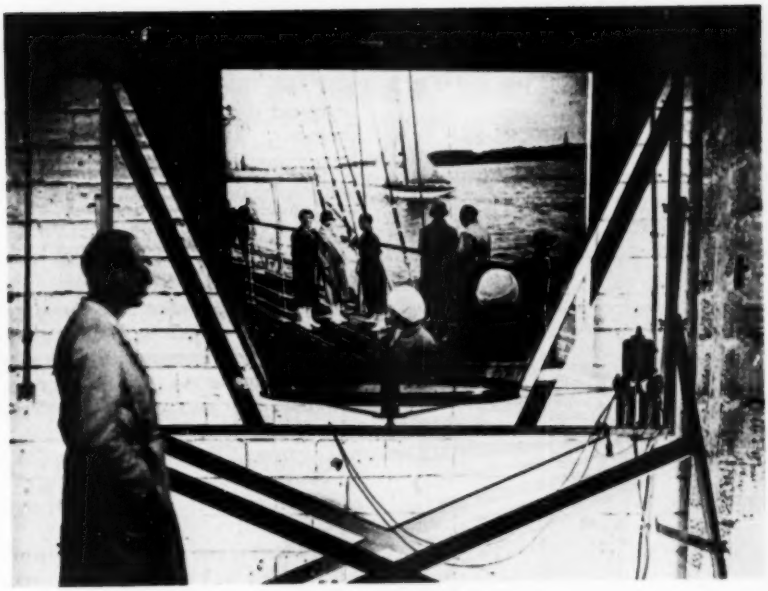

Figure 7.

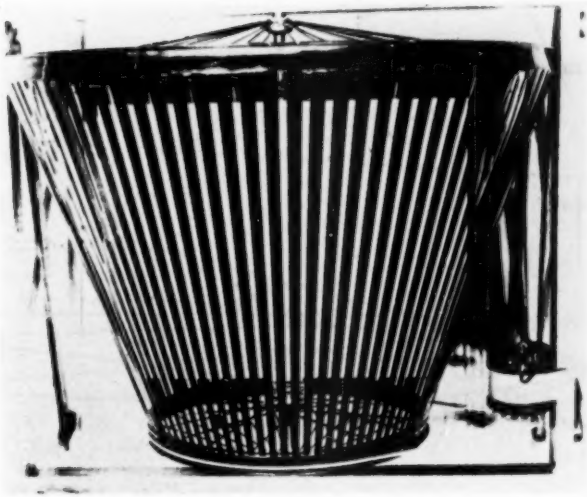

Figure 8.

an angle of 20° to the screen. The spacing must be accurate and the ratio between the opening and the width of the bar is 3 to 5 at the top and 2 to 5 at the bottom.

The path of the selector grill is so designed as to have zones of vision every four degrees as shown in the seating arrangement in Fig. 9. The correct viewing distance is $2\frac{1}{2}$ to 6 times the width of the screen. It is simple to pre-set the seats in the vision zone of 40°. R1, R2, R3, R4 and R5 represent the rows of seats. G and D represent the vision zones. OG and OD represent the two images of the stereo-projector. The spectator will naturally keep himself in a suitable vision zone that is not rigid, so he may move his head slowly until the visual accommodations are most favorable.

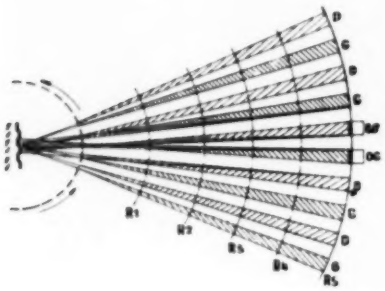

Figure 9.

The direction of rotation of the selector grill is from left to right, turning at a constant speed of four turns a second. When projecting motion pictures it was found necessary to use a synchronous motor to turn the grill, to eliminate any stroboscopic interference with the projector's shutter.

The overall light-loss in projection on the large screen shown in Fig. 7 is estimated to be in the neighborhood of 50%.

This screen can be fabricated in most sizes up to a 10-ft grill. We understand, Mr. Savoye is now engineering

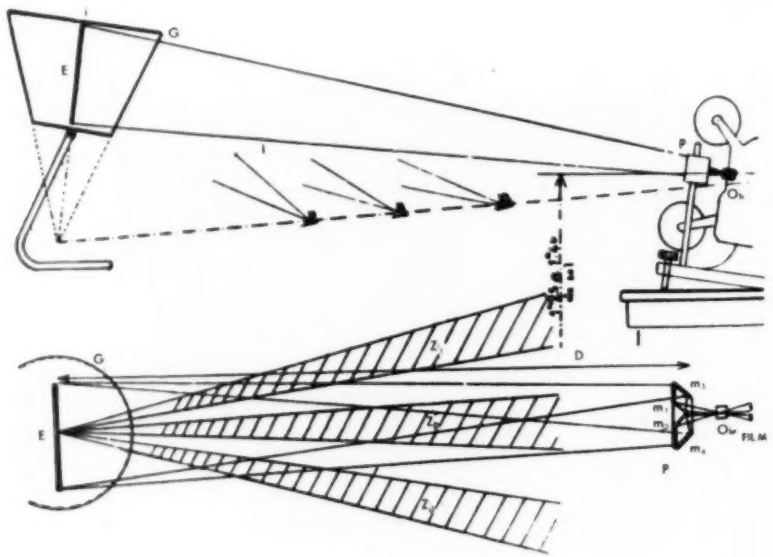

Figure 10.

a theater-size screen for an auditorium seating 500.

The projector must be located behind the spectator as illustrated in the upper half of Fig. 10. When projecting a very short distance, the screen should be tilted forward about 5°. The lower half of Fig. 10 illustrates the projection of stereo-pairs from a single film by the use of beam-splitter P mounted on the front of the projector lens. The vision zones Z1, Z2 and Z3 are the same as shown in Fig. 9.

We will not attempt to discuss the various types of beam-splitters and lenses used in taking and projecting 16mm and 35mm motion picture stereo-pairs. This is a specialized technical subject that requires individual treatment.

There is a great interest in color stereo motion pictures. They have a definite application in the fields of education, industry and science. Everywhere three-dimensional color motion pictures have been exhibited, they have had a tremendous audience appeal.

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Automatic Torque Controller for Torque Motors

By CARL E. HITTLE

The use of the automatic torque controller permits the full advantages of torque motors to be realized for film take-up and holdback duty without being handicapped by their inherent limitations when operated in the conventional manner.

SINCE THE FIRST sound-on-film recording and reproducing units were made, many types of film-spool drives have been used on such apparatus. During the intervening years, film-spool drives ranging from the slipping belt to friction clutch, and, more recently, to torque-motor types have been used. When torque motors became available it was believed that they would provide the ultimate in performance, possessing more advantages than the previous types of drives and none of the disadvantages. Experience with these motors taught us that in the latter respect this was not true. As with the belt and the friction clutch drives, we found that torque-motor drives may also adversely affect the steadiness of film motion in the apparatus. Since the characteristics of torque-motor drives in connection with their use for take-up and feed spools in film-pulling mechanisms have been presented previously before the Society in a paper by A. L. Holcomb,* only the manner in which they may affect film motion will be reiterated. As stated in Mr. Holcomb's paper, these adverse effects may result from the following:

1. Sprocket-hole flutter (96 cycle/sec) due to high film tension at beginning or end of a reel.
2. Erratic shifting of the film with respect to the sprockets at "crossover" where the net tension on the film reverses.
3. Gear train chatter due to unloading the sprocket gears at crossover.

All of these contributing factors may be eliminated by maintaining constant film tension throughout the roll between each film spool and film sprocket with a differential in tension between

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by Edward P. Ancona, Jr., for the author, Carl E. Hittle, Radio Corporation of America, RCA Victor Div., Engineering Products Dept., 1560 N. Vine St., Hollywood 28, Calif.

* A. L. Holcomb, "Film-spool drive with torque motor," *Jour. SMPTE*, *58*: 28–35, Jan. 1952.

the take-up side and the drag side, tension on the latter side being of lesser numerical value. Film tension may be controlled and maintained within satisfactory operating limits by means of the automatic torque controller for torque motors to be described herein. It is equally useful whether the motor is used as a take-up or drag device. The principle of operation of the controller

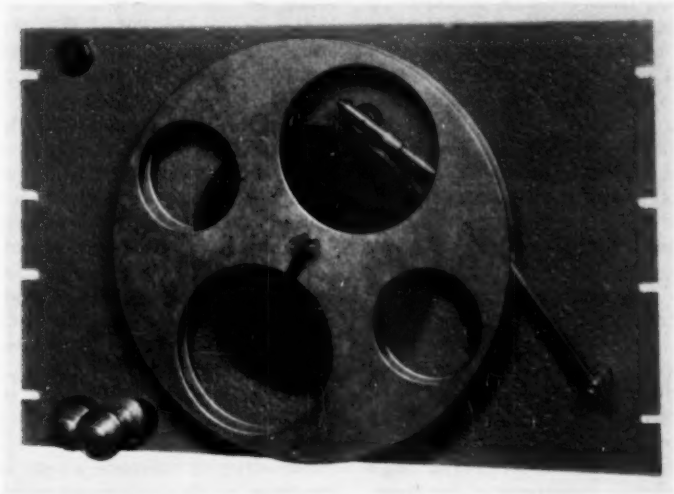

Fig. 1. Torque Controller — front view.

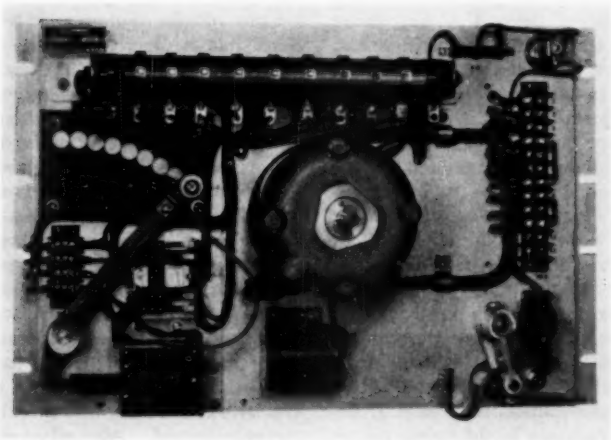

Fig. 2. Torque Controller — rear view.

is based on the fact that the torque produced by the motor may be varied by changing the voltage to the motor.

Principal elements of the controller consist of the following: a film roll follower mounted on a rotatable arm, a multistep rotary switch actuated by the rotatable arm, a set of resistors having as many adjustable contact bands as there are steps on the rotary switch, a solenoid, a relay, and interconnecting wiring.

The film roll follower arm assembly is mounted on the front side of the reel panel as shown in Fig. 1. The remainder of the mechanism is mounted on the back side of the panel together with the torque motor.

When used in conjunction with the motor serving to drive the take-up spool or reel, the device functions in the following manner. Sufficient resistance is introduced in series with the motor at the start of the roll during take-up to reduce the film tension to the desired value. Thus the usual initial high film tension is eliminated at the beginning, thus removing this cause of sprocket-hole flutter. The torque controller functions in a manner to maintain film tension relatively constant. As the diameter of the roll of film being wound on the take-up spool increases, the roller on the follower arm is moved farther from the center of the spool, causing the shaft to which the arm is attached to be rotated. The rotary switch contactor arm, mounted on the opposite end of the shaft, is moved gradually across the step contacts of the switch shown in Fig. 2. Sufficient free movement has been provided in the mechanical assembly to prevent rotational eccentricity of the roll of film from causing oscillation of the contact brush across adjacent switch steps. The gradual operation of the rotary switch causes small incremental decreases of resistance in the motor circuit resulting in a gradual increase in motor voltage. This, in turn, due to the electrical characteristics of the torque motor produces an increase in motor torque.

As applied herein, torque may be defined as the product of a force multiplied by a moment arm. In terms with which we are concerned, film tension and radius of the roll of film are the force and moment arm members, respectively, of the torque equation.

With proper adjustment of the positions of the resistor contact bands, the torque may be controlled so as to maintain the film tension constant within approximately 2 oz. Based on a normal tension of 11 oz, the 2-oz variation is less than 20% deviation. Should one attempt to use 2000-ft rolls with standard 2-in. film cores on apparatus equipped with friction clutch or standard torque-motor take-up drives, the deviation would be on the order of 600%. This deviation in tension would be nearly 400% for 1000-ft rolls under the same conditions.

The drag or holdback torque motor functions in the inverse manner from that for take-up. To prevent free-wheeling of the roll of film with the motor power off, a friction clutch is incorporated in the mechanical assembly of the motor and reel shaft. Since this available friction is sufficient to provide holdback as the diameter of the roll of film approaches the core, motor power is turned off when the roll is reduced to a predetermined diameter. This is accomplished by means of a relay, shown in Fig. 3, which is energized from the main motor switch that controls the direction of film travel through the apparatus. When the relay is energized, the electrical connections between the last two steps of the rotary switch and their associated resistor contact bands are opened. Then, when the rotary switch arm contacts either of these two steps, the electrical circuit to the motor is opened. Also, when energized, the relay causes additional resistance to be imposed in the electrical circuit to

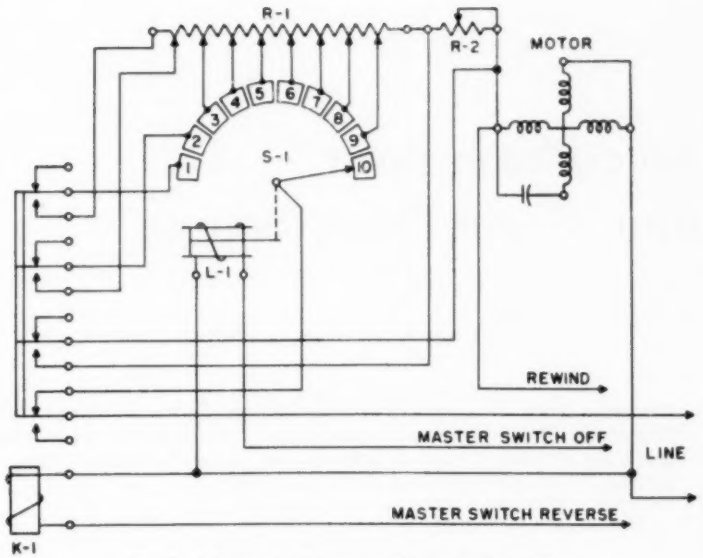

Fig. 3. Schematic diagram of Torque Controller.

obtain the decreased torque required when the motor is used for holdback. Operation of the device in the above manner serves to maintain a lower value of film tension for holdback operation than for take-up with no change required in the settings of the resistor contact bands for change-over from take-up to holdback duty.

Maintenance of holdback tension in proper relation to the take-up tension results in the elimination of: (1) reversal of the net film tension and its resultant shifting of the film on the sprocket plus gear train chatter, (2) high film tension at the end of the reel which otherwise would tend to produce sprocket-hole flutter.

An automatic follower arm lift has been provided to facilitate placement of a reel or spool of film on the reel spindle or removal therefrom. Lifting of the arm to its extreme rotational position from the spindle is accomplished by means of the solenoid, shown in Fig. 3, which is energized when the main motor power switch is in its OFF position.

The automatic torque controller as illustrated is suitable for use on magnetic recorder-reproducers or photographic reproducers having film handling capacity on either reels or spools up to 2000 ft. Its use is particularly advantageous in eliminating the extremely high film tension which results when 2000-ft rolls wound on standard film cores are used. Obviously the same principle may be applied for reels of larger diameter.

Three-Phase Power From Single-Phase Source

By A. L. HOLCOMB

Described is the development of a nonrotating device for the conversion of single-phase 115-v power to a three-phase 230-v form for the synchronous operation of cameras, sound recorders and other film pulling mechanisms associated with production of motion pictures.

THREE-PHASE MOTORS provide several desirable characteristics which are not supplied by single-phase units of equivalent power, and these characteristics, which include smaller size, lighter weight and quieter performance, are of particular value for the operation of cameras in motion picture production. Unfortunately, three-phase power lines are seldom available for location work outside of the studio lot, whereas the single-phase, 115-v source has become readily available in a large percentage of locations. Since sound recorders can conveniently be driven by single-phase motors, due to higher permissible noise, and to less rigorous weight-space requirements than cameras, it has become apparent that a synchronous converter from single-phase, 115-v, to three-phase, 230-v, for camera operation would be a desirable device. This would permit the operation of all channel equipment from a single-phase source without degrading camera performance.

A nonrotating device is preferable for reasons of noise and maintenance and while several such units are commercially available for this duty, they are not well fitted for camera drive since they require factory adjustment for the particular motor and load which the unit is to supply. Operation with other motors or different loads causes phase unbalance which can create operating noise and/or limit the maximum power obtainable from the motor, thus destroying the very features for which a three-phase motor is desirable. Since most cameras used in motion picture production vary widely in power demand with temperature change, it is only by chance that the factory adjusted phase balance is optimum for any given location condition. If the maximum power condition of the motor is selected for phase balance, an unbalance and noisy operation exist for all lesser loads while adjustment for balance at light load reduces the maximum power obtainable.

Presented on April 25, 1952, at the Society's Convention at Chicago, Ill., by John G. Frayne for the author, A. L. Holcomb, Westrex Corp., 6601 Romaine St., Hollywood 38, Calif.

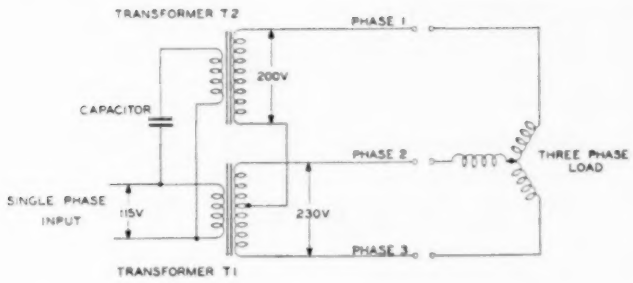

Fig. 1. Simplified schematic of the Converter.

Thus, it appears that a satisfactory single-phase to three-phase converter for camera operation must provide either a circuit that does not unbalance when supplying different motors and varying loads, or one which provides some clear indication of unbalance and a ready means of correction which is not too complicated for field adjustment.

Consideration of the problem indicates that the required phase shift from two conductors electrically 180° apart to three conductors displaced 120° cannot be obtained on a nonrotating basis without introducing reactance in various forms in the conversion circuit. Since the electrical load is also reactive, it will combine with the circuit reactance to determine the phase shift obtained unless isolation can be introduced between the conversion circuit and motor. Adequate isolation does not appear to be practical because of space-weight and efficiency factors and thus the motor reactance which varies from motor to motor and with load on any given motor must be considered as a component part of the conversion circuit. Therefore, a conversion circuit which will inherently maintain phase balance in the presence of the prescribed conditions is not considered practical, and as a result development has been focused on the alternative method, which would provide convenient indication and adjustment.

Basic Circuit

The Scott transformer connection, which is relatively old in the art and described in most electrical engineering handbooks, is the basis of the conversion circuit shown in Fig. 1. This transformer connection was originally used for the conversion of two-phase to three-phase or vice versa. By the addition of a capacitor of the right value in series with the primary of transformer T2, as shown in Fig. 1, the current in this primary can be shifted 90° with respect to the primary of T1 and thus the equivalent of a two-phase primary circuit is provided from a single-phase source. In the secondary, a three-phase electrical displacement exists only when connected to a balanced three-phase inductive load, which is the load condition presented by a three-phase motor.

The circuit functions to produce 120° phase displacement between the three output leads by means of the vector addition of both a proper voltage and a 90° phase shift with respect to the mid-tap of T1. A portion of the inductive load is reflected through T2 where it is effectively resonated at line frequency by the series capacitor. This provides the 90° phase shift mentioned, since at resonance there will be no reactive component in the primary of T2 and the current will be in phase

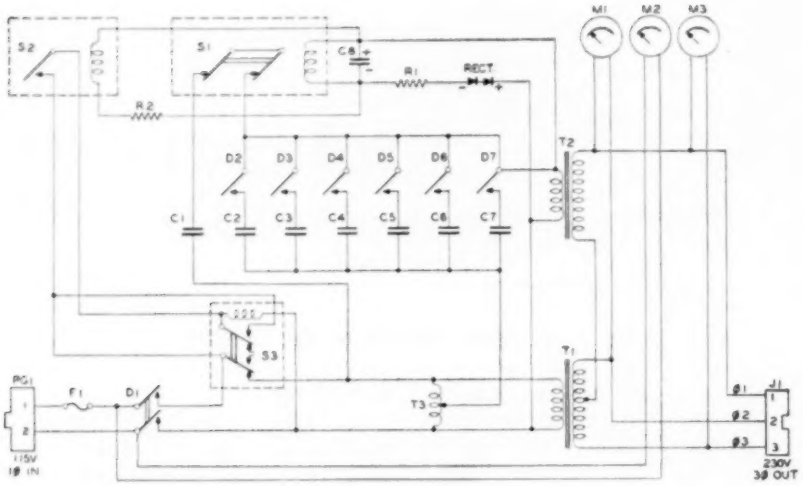

Fig. 2. Schematic of the Converter.

with the voltage. The current in the primary of T1 will lag approximately 90° since it is predominantly inductive. The secondary voltages of T1 and T2 will thus be 90° out of phase and if the secondary voltage of T1 is made 230 v and that of T2 is 200 v, then the voltage between the lead marked Phase 1 and either Phase 2 or 3 will be: $E_{T1/a} + jE_{T2}$ or 230 v. As combined in the load, the currents in all three phases are approximately 120° apart.

From the above it becomes apparent why such circuits require adjustment to a specific load condition since a variation in either phase or voltage of the secondary of T2 will upset the three-phase balance and both factors will vary with any change in impedance or inductance of the load. It also becomes apparent that this correction must provide a separate adjustment of the capacitor to match the load inductance in addition to a voltage correction for T2.

Developed Circuit

Development of the basic circuit for actual use is shown in Fig. 2. The transformers T1 and T2 appear in the same form as in Fig. 1, but the single capacitor is replaced by six units (C2 to 7) of such sizes that they provide any value from 1 to 60 μf in 1-μf steps and are readily connected as required by means of individual switches. These are oil filled a-c capacitors rated at 330 v. An additional capacitor shown as C1 is an a-c electrolytic unit of 100-μf capacity normally connected in parallel with the others through the relay S1. This is a necessary feature since the impedance of a synchronous motor is very much lower at the instant of starting than when running; therefore, the capacitance required to approach resonance at line frequency is several times greater at start than is desirable for running phase balance at even maximum load. Unless this initial high capacitance is provided, the output is essentially single-phase and the motor will not start. C1 meets this condition for the short start time and is automatically disconnected by the relay S1 when the voltage across the primary of T2 reaches 100 v. The current supply

to the coil of S1 is rectified to avoid chatter of the relay contacts at break. The coil of relay S2 is in parallel with that of S1 through a resistance which prevents operation of S2 unless or until the voltage rises to 300 v. This provides protection for the running condensers in case the load is disconnected while the operating switch D1 is closed. Opening the output circuit of phase 1 allows the voltage of the resonant circuit in the primary of T2 to rise well above the condenser rating unless this protection is provided. S2 in turn operates the relay S3 which opens the input circuit and locks up in this position until the input potential is removed.

Tap changing on T2 was considered as an alternative method of resonating the primary with a single condenser, but this was abandoned since tap changing in such a resonant circuit causes excessive arcing, and because adjustment equal to that obtained by six condensers and switches would require a sixty-point tap switch.

Voltage adjustment for T2 may be obtained without phase shift by means of series resistance in the resonant circuit or by resistance shunted across the primary of T2, but either method results in serious I^2R losses. The Variac T3 when connected across the input line, as shown, functions as an efficient voltage divider and does not contribute a reactive component to the resonant circuit since the exciting current is supplied by the line. Also, the range of adjustment is wide and very smooth.

The three small voltmeters M1, 2 and 3 are the indicators used to determine and maintain phase balance. M2 is a 150-v meter connected across the incoming line which serves as a pilot meter on the single-phase supply, and also effectively indicates the voltage across phase leads 2 and 3 during operation since this voltage is twice the line voltage except where a heavy load may introduce appreciable I^2R loss in T1. M1 and M3 are 300-v meters across the other two output phases. With this arrangement, both three-phase output and single-phase input are shown in addition to the basic function of balance indication.

Adjustment and Operation

The selection of the proper capacitance in the primary circuit of T2 need only be determined once for any given motor and line frequency. Therefore, this information may be obtained in the shop before the camera goes on the set or location. Once obtained, the condenser values for different motors, or combinations of motors, may be tabulated and attached to the converter for ready reference.

To determine capacitor value, the motor is connected for operation, preferably driving a camera or other normal load. The condenser values of 1, 2, 4, 8, 15 and 30 μf are marked on the plate adjacent to the switches which connect them in parallel. Thus, the values shown are additive as the switch handles are toward the marked plate. About 25 μf should be connected as a preliminary value of capacitance for 60-cycle operation (approximately 35 μf for 50-cycle). The Variac is positioned about center and the motor started by closing the "line" switch D1. The two outside meters M1 and 3 are then observed and the Variac adjusted until they read alike. If this balanced reading is higher than the pointer position of the middle meter M2 (twice the indicated voltage) then the capacitance should be reduced, or vice versa, and M1 and 2 again balanced by Variac adjustment. This is continued until all three meters show the same pointer position. With very little practice this adjustment can be accomplished in less than a minute. Having established and noted the capacitor value the unit is ready for operation; further adjustment for load variation being made by changing the Variac to make the pointer of M1 read the same as

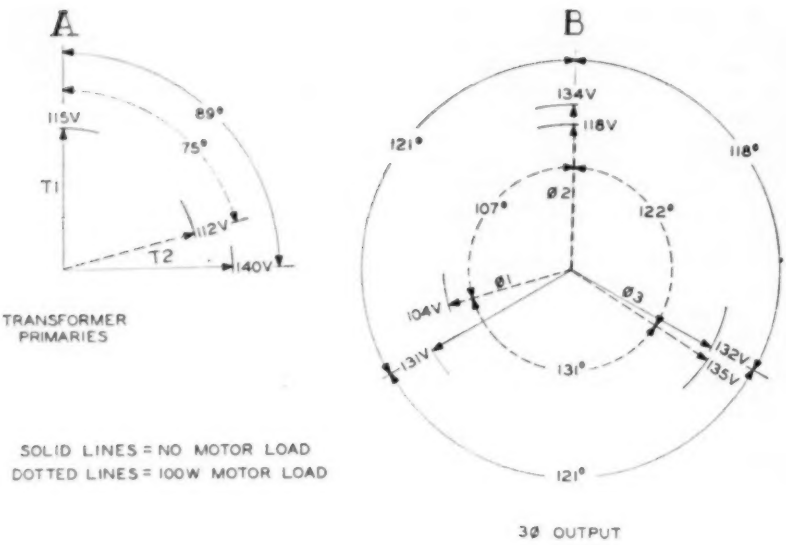

Fig. 3. Phase-voltage relations — without load correction.

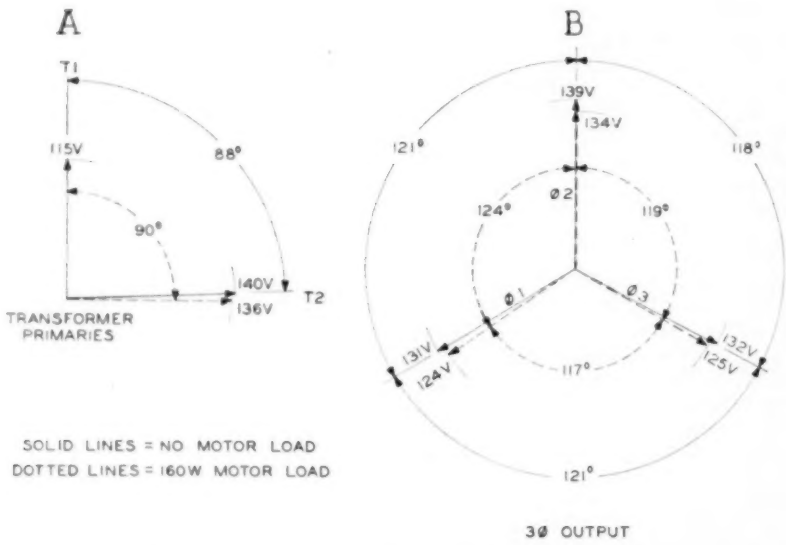

Fig. 4. Phase-voltage relations — with load correction.

M2 ± a few volts. In either initial or subsequent balancing, it will be found that both M1 and M3 vary in the same direction with each other and with the Variac. However, M1, across phase 1 and 2, varies more rapidly than M3, and M2 does not change except with input voltage.

In operation, the converter may be located at the camera and the "line" switch D1 used as the camera operating switch, or the unit may be positioned at the recorder with any individual or common switching desired. In mild weather where temperature and camera load do not vary greatly, the initial load adjustment of the Variac might well remain the same for several days shooting. In case of cold weather, however, some cameras will warm up enough in a long take to change load by a factor of 2 or 3. Adjustment of the Variac to meet this condition may be made during a take without disturbance to either picture or sound. It should be noted, however, that precise adjustment is not essential to operation and under average conditions the unit can be forgotten unless the camera motor becomes noisy or lacks power.

Where recorder and camera are both operated from the converter, either motor may be dropped off at will. The phase balance will be materially upset and the remaining motor will be noisy but the recorder is usually too far from the microphone to cause trouble, and if the recorder is cut off, the camera noise does not matter.

Performance

It is obvious that the voltmeters used as indicators of phase balance actually show only voltage across the three phases and indicate phase relation indirectly if at all. Thus, this method of indication may well be questioned. Since the voltages indicated are each a resultant of two voltages to the mid-point of the load, which in turn are the resultant of a vectorial addition of both voltage and phase relation, the theoretical reasons why such indications are of value become involved and tedious and will be omitted in favor of measured results.

A true picture of the voltage conditions in the load can be obtained by measuring the voltage from each phase lead to a mid-tap on a star connected load. In addition, a method was devised which indicated voltage phase relations across the same points, and across T1 and T2 primaries, to an accuracy of $\pm\frac{1}{2}°$. The currents in each leg of the load are not in phase with the voltage but bear the same relation to each other as the voltages since the load is electrically symmetrical. With the above arrangement, it was possible to obtain an accurate picture of phase-voltage relations under varying load conditions.

A motor fairly typical of three-phase synchronous camera motors was operated through the converter from a 115-v single-phase source and adjusted for capacitance balance at no-load in the manner previously outlined. The accuracy of balance in each case was probably of the order of ±2 v; about what would be expected in normal use.

Figure 3 shows the phase-voltage relations without correction for load change. In Fig. 3A the primary of T2 is compared to the primary of T1 which latter is also the line input and does not change with load. The solid line shows T2 at 140 v displaced 89° from T1 when the motor ran no-load. When the load was increased to just under pull-out, the voltage dropped to 112 v across T2 and the phase relation to T1 became 75° as shown by the dotted line. In Fig. 3B of the same figure is shown the resultant conditions existing in each phase winding of the motor. At no-load as again shown by the solid lines, the voltages to the mid-point were between 131 and 134 v with phases 121, 121 and 118° apart. With 100-w load on the motor, phase 1 has

Fig. 5. Engineering model of the Converter.

dropped to 104 v and shifted to 107° from phase 1 and 131° from phase 3, phase 2 has dropped to 118 v while phase 3 has shifted 4° and increased voltage slightly. As a result, the motor was noisy and the maximum stable power obtainable was reduced from 160 w mechanical to 100 w or 62½% of normal. This was chiefly due to the changes in phase 1 with some contribution from the reduced voltage in phase 2; the voltage change and phase shift of phase 3 being of little importance. In this connection it was found that unbalance of 10 v between phases, or 5 to 6° departure from the ideal, did not create noticeable noise or power reduction unless these factors combined.

Figure 4 is similar to Fig. 3 except that correction for increased load was made, as described, by means of the Variac T3. In Fig. 4A the phase shift and voltage change in the primary of T2 is small, being 2° and 4 volts, respectively. In Fig. 4B the phase shift in the motor windings is negligible (3° maximum) although some voltage unbalance exists due to an increase in voltage of phase

2 while phases 1 and 3 are reduced alike. This unbalance is not too serious and it appears only when capacitance balance has been made at no-load and load correction has been stretched to cover the whole power range of the motor. It should be noted in this connection that the motor load is 160 w under the conditions of Fig. 4 which is the same maximum power which this motor can deliver from a normal three-phase line.

Power Characteristics

Power output capacity sufficient to handle any motor or combination of motors would be desirable. Since this cannot be provided in a portable device, the maximum weight which can be carried by one hand (about 50 lb) was used as a base, and as much power as possible was provided within this limitation rather than selection of some arbitrary value of power. The result of this approach is a power output of about 400 va; the real watts and available mechanical power being determined by the power factor and efficiency of the motor. The engineering model is shown in Fig. 5.

The single-phase input power factor is relatively good and varies from 50 to 95%, while the conversion efficiency from single-phase to three-phase varies from 30 to 75%; both factors depending on the characteristics of the motor load.

In terms of equipment which can be operated by the converter, the following motors or combinations of motors appear to be within the power handling range of the unit:

Standard camera, synchronous motor — limited only by motor power
Standard camera and portable recorder, synchronous motors — above 50 F ambient
Standard camera and portable recorder, multiduty motors — any weather
Technicolor camera — above 50 F ambient

As previously noted the load demand of most cameras varies widely with ambient temperature and the weather is thus noted as a limiting load factor in some cases. Multiduty motors* operated in the synchronous mode function at relatively high efficiency and good power factor and thus heavier loads and/or more motors are operable from the converter than is the case with the usual variable reluctance synchronous type. It should be noted that the inclusion of this converter in a multiduty equipped channel adds single-phase, 115-v supply to the existing battery and three-phase power sources from which such channels can operate.

Conclusion

The development of a portable, nonrotary converter to supply three-phase, 230-v from a single-phase, 115-v source has seemed desirable in order to realize the inherent advantages of three-phase motors, particularly on motion picture cameras, while utilizing the convenience and availability of single-phase source of supply. Good phase-voltage balance is essential in such a device under variable load conditions, and it has been possible to obtain this by providing a simple form of indication together with a ready means of correction.

Discussion

William P. Kruse: Approximately what is the primary voltage on your resonant transformer during some various normal loads?

(*Communicated by*) *A. L. Holcomb:* The primary voltage of T2 is maintained essentially constant at 135 volts by adjustment of the Variac, as described, to meet the various load conditions.

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*A. L. Holcomb, "Motor systems for motion picture production," *Jour. SMPE, 42:* 9–33, Jan. 1944.

Continuous Arc Projector Light Meter

By HARRY P. BRUEGGEMANN

This is a system for monitoring the light output of an arc projector during projection. It comprises a piece of optically flat glass, not silvered, placed in the projector light path, at an angle of 45°, and ahead of the film gate. The light thus thrown off to the side is measured by a photovoltaic light meter.

ARC PROJECTORS are normally built for theater projection, and they are designed to give a picture of pleasing quality. However, when arc projectors are used as laboratory production equipment for timing prints or for side-by-side comparison of prints, they must meet certain rigid specifications. One of these is the maintenance of an absolutely steady light output.

Experience at Cinecolor has been that arc projectors vary in their light output by as much as 20% during a 10-min projection, in spite of good operational practices and frequent equipment maintenance. This variation, of which the projectionist has no indication, seems to be due to the carbon feed, slight imperfections in the carbons themselves, voltage fluctuations and mechanical variables. A 20% change in light output would probably never be noticed in a theater, provided it is gradual enough. To a timer though, who is attempting to adjust scene densities to within one-half of a printer point of what the producer wants, a change of this magnitude is too great.

A number of systems for controlling the arcs were investigated. One such system consisted of a photoelectric cell, the output of which would control a thyratron, which in turn would control the carbon-feed motor in such a manner as to maintain a constant luminosity. This has the advantage of being automatic, the control being maintained without requiring an adjustment by the projectionist. As far as could be determined, there was no such thyratron arc controller on the market, hence it would have to be designed. Since Cinecolor already had some experience in designing thyratron controlled light sources, it was realized that this undertaking would be very expensive. All types of photoelectric light meters were eliminated, also, because of design expense.

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by George W. Colburn for the author, Harry P. Brueggemann, Cinecolor Corp., 2800 W. Olive Ave., Burbank, Calif.

The only system which seemed feasible would make use of a photovoltaic cell type of meter so arranged as to keep the projectionist continually informed as to the light output of the projectors. With this guide, he could maintain the light at the standard value by trimming the arc. A photovoltaic cell is practical because it maintains its calibration quite well if protected from heat, moisture and intense light. Since a great deal is known about the use of photovoltaic cells as light meters, design of such a system should be relatively simple.

Accordingly, a projector light meter was built around a photovoltaic cell. In order to monitor the light actually reaching the screen, a piece of unsilvered, optically flat glass was placed in the light path at an angle of 45°. This threw a beam of light off to the side of the projector, amounting to approximately 10% of the total output. This was more than enough for any photovoltaic cell, and at the same time caused a loss of only 10% in the screen brightness. This could be compensated for by trimming the arc. Obviously, the glass had to be positioned between the arc and the film gate.

The photocell was a Weston Photronic cell type RR, and the associated ammeter was a 0 to 20-μa, 2500-ohm Weston meter. Since the light from the optical flat was far too much for the cell, a means of attenuating this light was necessary. A dense green glass was placed ahead of the cell in the first model. This cut down the light to a workable level, but permitted a great deal of infrared radiation to be transmitted. This infrared energy raised the temperature of the cell too high for stability, so an Aklo heat glass was added. This promptly cracked. Thus it was evident that another means of reducing the heat was necessary. Ventilation slots were cut into the casting holding the cell, and this helped some, but the Aklo glass still would not stand up.

At this point the projectionists at the M-G-M laboratory, who had been informed of our project and had built a model of their own, thought of replacing the dense glass filter by a sheet of brass shim stock with pinholes. This solved the excess heat problem, since the infrared radiation was reduced as much as the light. The first Cinecolor model used a bakelite mounted photocell, but M-G-M used a metal-encased cell for conduction cooling. The M-G-M modifications resulted in a cell mounting which was only slightly warm to the touch, even after many hours of continuous operation.

The Weston microammeter, with its 2500-ohm resistance, gave a fairly linear response when coupled to the type RR Photronic cell. Various devices were considered for improving the linearity, including shunt resistances, lower resistance ammeters, and other types of photocells; but they all required more light, and consequently would have placed more heat at the photocell. Since heat dissipation was the biggest problem of the project, it was decided to accept the slight nonlinearity. The only advantage to improving the linearity would be to eliminate the scale compression in the operating range and thus increase the sensitivity. With the present model of the meter, however, luminosity fluctuations can be kept within about 3% and this is considered good. Most of this fluctuation is due to the coarseness of the trim, not the accuracy of the meter.

The location of the unit in the projector is shown in Fig. 1. This view shows the first Cinecolor model mounted in a Simplex projector, just above the framing knob. The rear end of the photocell, showing the bakelite casing, is seen together with the two wires leading to the microammeter. The ammeter is mounted on the wall of the projection booth just below the viewing

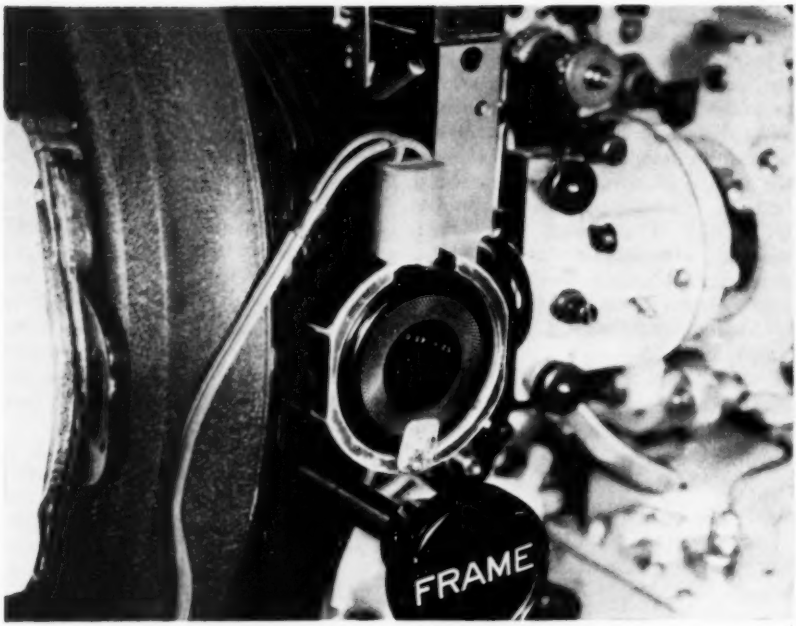

Fig. 1. View of the first Cinecolor model mounted in a Simplex projector.

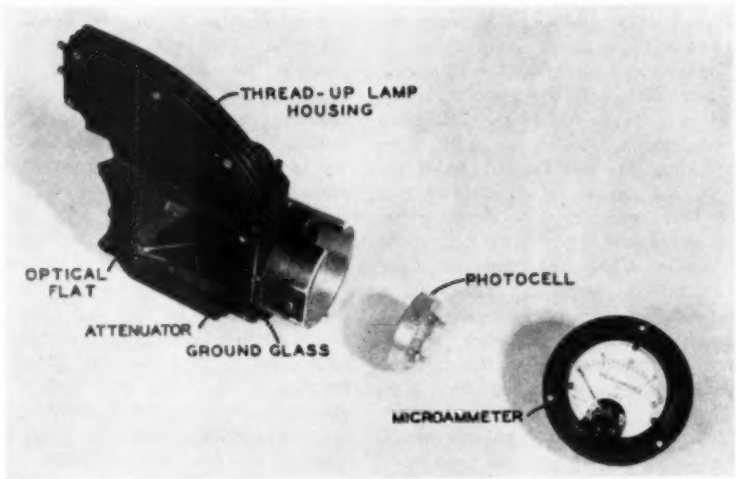

Fig. 2. The three basic units of the second Cinecolor model.

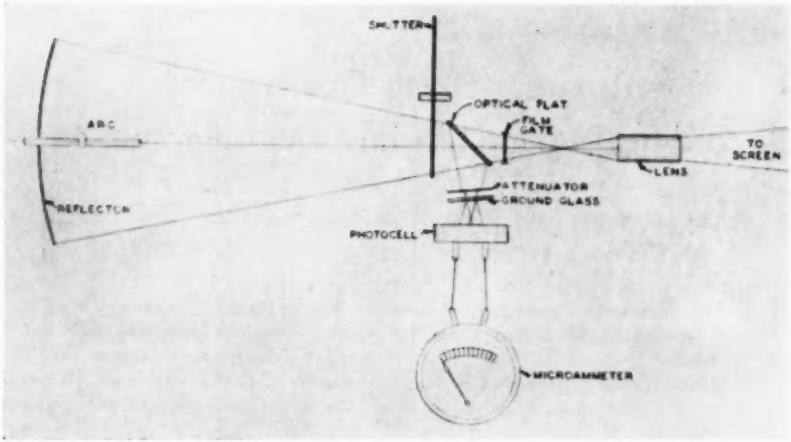

Fig. 3. Schematic of system — top view.

port, so that the projectionist can see the screen and the meter at the same time. Figure 2 shows the three basic units of the second model — the optical flat and brass attenuator mounting, the metal-encased photocell, and the microammeter. The optical flat occupies the space normally used by the thread-up lamp when it is lowered for threading up. The lamp was repositioned so that it missed the optical flat when lowered. The perforated brass attenuator slides into a slot cut just ahead of the photocell housing. The edge of the attenuator is visible in the figure. There is a ground glass immediately behind the attenuator to break up the light through the pin holes, and thereby avoid any local "hot spots" on the surface of the photocell. Figure 3 is a schematic drawing of an arc projector with the unit installed.

In operation, the system requires only a 5-min warm-up period in the morning, after which it will remain constant all day. The warm-up is necessary because the photocell has greater sensitivity when cold, and temperature equilibrium must be reached before the system stabilizes. During projection, the operator needs only to keep the needle at a constant standard value by appropriately trimming the arc. The use of this system has resulted in a great improvement in projection quality, both at Cinecolor and M-G-M.

Thanks are expressed by the author to James Phillips, Chief Projectionist at Cinecolor, for initiating and doing most of the original work in this project, and at M-G-M to Merle Chamberlain, Chief Projectionist, and Clayton C. Troxel, Jr., Projection Engineer, for their modification which contributed to the success of the final model.

Use of a Rotating-Drum Camera for Recording Impact Loading Deformations

By D. F. MUSTER and E. G. VOLTERRA

The details of a rotating-drum camera are described. The camera is used to record displacement-time data for short cylindrical specimens made of a rubberlike material which are subjected to compressive impact loadings lasting from 5 to 20 milliseconds. The auxiliaries to the camera are discussed in light of the particular needs of a study being conducted on the dynamic properties of plastics and rubberlike materials.

An INVESTIGATION on the dynamic stress-strain properties of plastics and rubberlike materials is being conducted at Illinois Institute of Technology under the sponsorship of the Mechanics Branch, Office of Naval Research, as part of their basic research program on the properties of materials.

For determining directly the stress-strain curves of plastics and rubberlike materials subjected to impact loads, the duration of which are of the order of milliseconds, a special apparatus has been built which uses mechanical and optical devices. The paper is confined to only a brief description of the optical parts of the apparatus, and particularly of a special rotating-drum camera and its accessories which is used to record displacement-time data for the specimens being tested.

The apparatus employed in the experiments is shown in Figs. 1, 2 and 3. It consists essentially of:

(1) two 3-ft, 1-in. diameter steel bars, of equal mass, suspended as ballistic pendulums;

(2) a rotating-drum camera, the drum of which rotates at a known speed, and the shutter of which is synchronized to operate with the motion of the steel bars;

(3) an optical system which focuses the image of a very thin slit on the knife edges machined on the adjoining ends of the steel bars; and

(4) an electromagnetic device which can release one or both of the bars at the same time.

The cylindrical specimens of plastics or rubberlike materials to be tested are $\frac{1}{2}$ in. in diameter and $\frac{1}{2}$ in. long. They are placed on the plane end of one of the steel bars such that the longitudinal axes of the bar and of the specimen coincide. The other steel bar is released from a predetermined height by a magnetic release mechanism and is made to impinge upon the free end of the specimen. During the impact a photograph is taken of the interval between the knife edges which lie in the plane of the ends of the steel bars.

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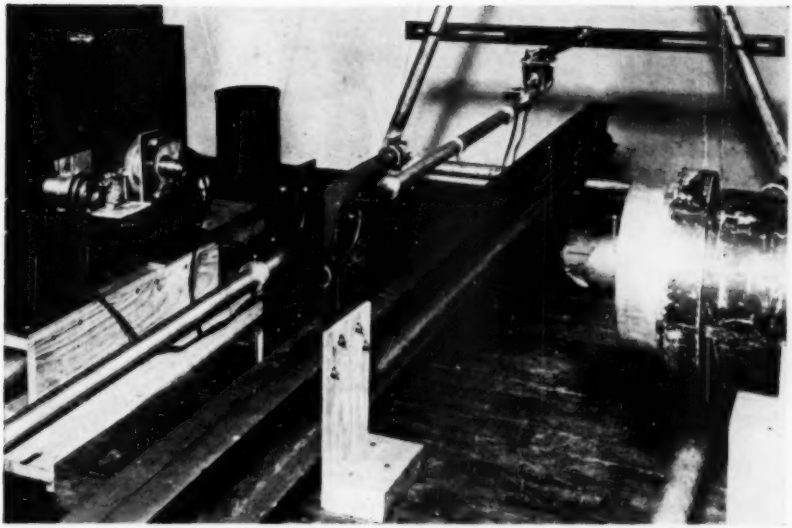

Fig. 1. Front view of camera.

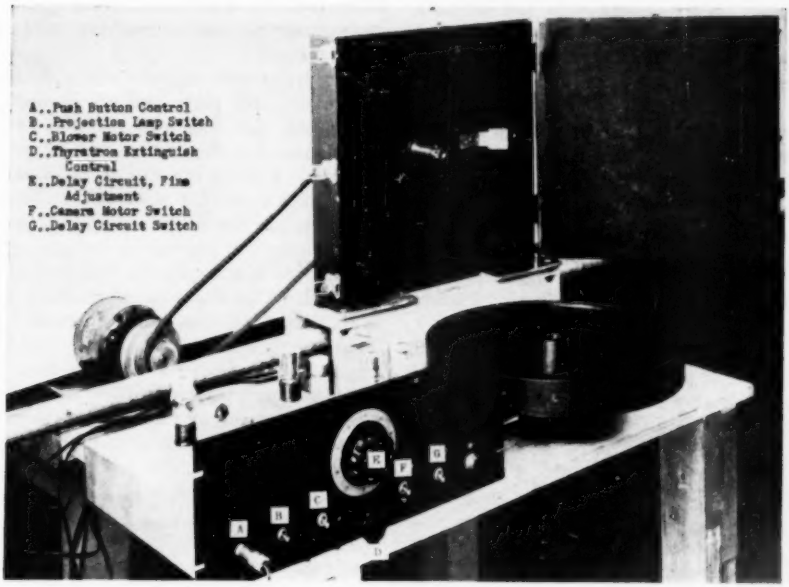

Fig. 2. Back view of camera.

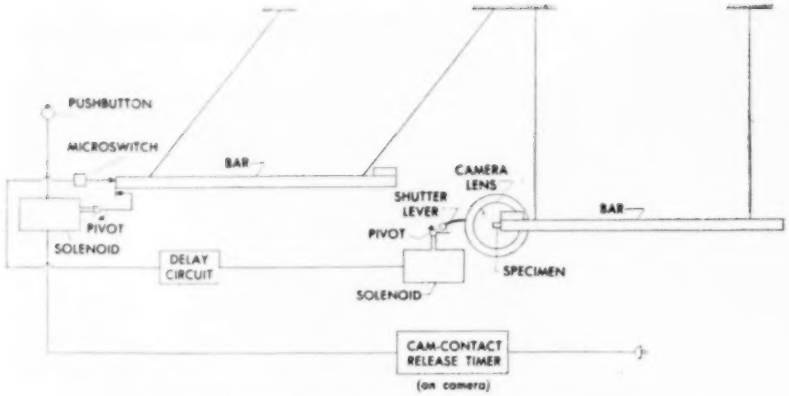

Fig. 3. Schematic diagram of equipment arrangement.

The magnetic release mechanism is controlled electrically by a cam device (shown on the camera shaft in Fig. 1), which serves to time the release of the bar with the position of the film on the drum. This insures that the exposed strip of film will not include the overlap region where the two ends of the film are joined.

A delay circuit is adjusted so as to cause the shutter mechanism to operate during the time interval of from 5 to 20 msec during which the impact between bar and specimen occurs. The record on the film strip is calibrated by superposing a still photograph of the distance between the two knife edges when both bars are just in contact with the specimen.

The data on the film strip are read by direct measurements made with a microscope mounted on a movable base. The base is fitted with two orthogonal motions and can transverse a maximum of 4.5 in. in increments of 0.001 in. From these data the displacement-time relationship is plotted.

The camera body is made of $\frac{1}{4}$-in. thick aluminum alloy plates. Front and back views of it are shown in Figs. 1 and 2. All joints have been sealed and the entire assembly painted dull black. The back of the camera body is mounted on hinges which permit easy access to the drum. The back is locked in position by four trunk-type fasteners and is light sealed by a $\frac{1}{16}$-in. thick neoprene gasket cemented to its inside surface.

The drum was turned from a 2-in. cold-rolled steel plate and its finished dimensions are indicated in Fig. 4. It is mounted in the camera on a keyed shaft with a large hex nut to facilitate easy removal in the dark. The film is placed on the inner surface of the drum and held in position by two spring-metal strips which grip the film strip at its edges. The drum accommodates a 48-in. length of film, which permits a slight overlap, and there is a useful length of approximately 40 in. of film.

In the drum periphery there are two $\frac{3}{8}$-in. radial holes that are used to focus the slit image on the film strip. There is a corresponding hole fitted with a sealing flap in one end of the camera body.

The drum is driven by a small induction motor rated at $\frac{1}{40}$ hp at 900 rpm. Through a belt and pulley arrangement, the speed of the camera drum is reduced

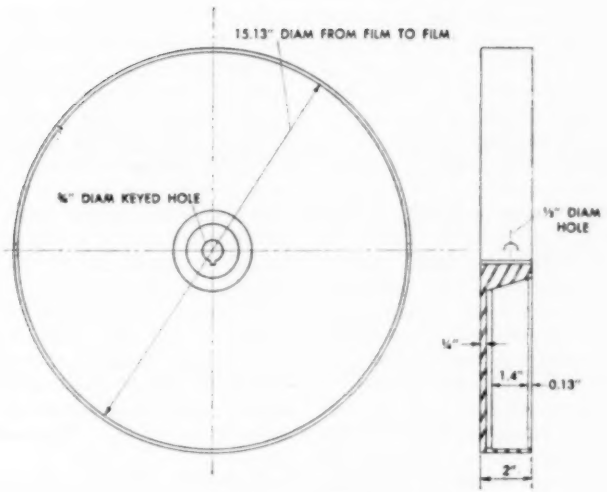

Fig. 4. Rotating drum.

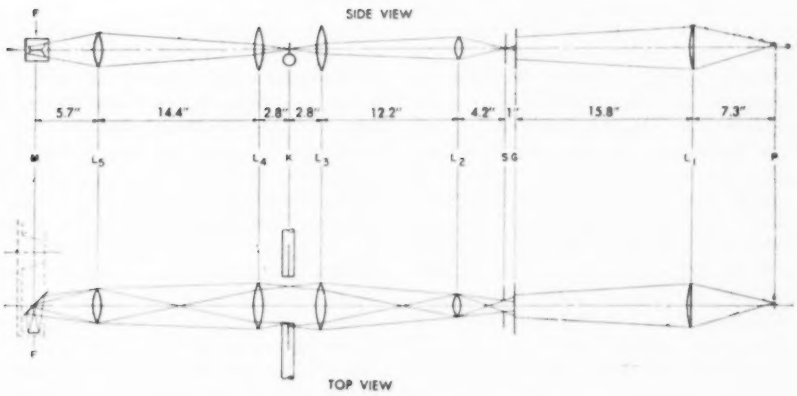

Fig. 5. Schematic diagram of optical system.

P. . . . Projection Lamp, GE 750T12P
G. . . . Ground-Glass Plate, 2 in. × 3 in.
S. . . . Slit, 0.001 in. × ¼ in.
K. . . . Knife Edges on bars
M. . . . Mirror, first-surface set at 45° to axis of lens arrangement
F. . . . Film, Kodak Linagraph Panchromatic LP421
L_1. . . . Condensing Lens, 6in. $f/1$, $4\frac{7}{16}$in. diam
L_2. . . . Projection Lens, 75mm $f/1$, 49mm diam coated achromat
L_3. . . . Plano Convex Field Lens, 17 in. $f/1$, $3\frac{1}{2}$ in. diam
L_4. . . . Plano Convex Field Lens, 21 in. $f/1$, $3\frac{1}{2}$ in. diam
L_5. . . . Camera Lens, Color Skopar $f/3.5$, 105 mm $f/1$

to about 120 rpm, an adequate speed for the shortest time during which impact occurs. The actual speed of the drum is measured just before and after each test by means of a Jagabi Speed Indicator accurate to within $\frac{1}{2}$ of 1%.

The optical system from light source to film on the camera drum is shown in Fig. 5. There is every possibility that other equivalent systems could be designed; however, the one shown in the figure was developed from the equipment and materials most readily at hand after a trial-and-error period in which the design was changed several times.

The light source (not shown in Fig. 1) is mounted in the air stream of a centrifugal air blower immediately behind the cylindrical tube which contains the condensing lens, ground-glass plate, slit, and projection lens, in that order. The impact phenomenon occurs between a pair of field lenses, the first of which serves to collimate the light rays and the second, to focus the collimated rays on the surface of the objective lens. The light path between the field lenses is partially blocked by the knife edges on the bar ends, the distance between the edges at each instant of time indicating the deformation in the specimen.

The camera lens, a Color Skopar I, *f*/3.5, 105-mm coated lens, focuses the slit image on the film by means of a first-surface mirror set at 45° to the axis of lens arrangement. The image is brought into focus by viewing it on a piece of exposed film set over the holes in the drum and the camera case (see Figs. 1 and 2).

There are two electronic circuits which are important to the proper operation of the camera:

(1) the timing circuit of the bar release mechanism; and

(2) the shutter delay circuit.

The former operates through a cam on the shaft of the camera and times the release of the impinging bar so that the exposed strip of film will not include the region of the splice. In order that the bar will be released two contacts must be closed, a pushbutton controlled by the laboratory technician and the cam timing contact which is preset. It is expected that the bars will have essentially the same periods from release to initial impact for all anticipated values of drop height. Thus, the cam setting should not have to be changed, except for minor adjustments, until very large drops are attempted.

The shutter delay circuit, as its name implies, causes the shutter mechanism to open the shutter just prior to the instant of initial impact. The actual exposure time is governed only by the speed of the drum and is preset on this basis.

Thus far, Kodak Linagraph Panchromatic LP421 film and Dektol (D-76) developer have been used with good results.

Summary

The rotating-drum camera described here has been built to record an impact phenomena, which occurs in from 5 to 20 msec, in order to determine directly some of the dynamic properties of rubberlike materials at high rates of compressive straining. The optical advantages of a one-to-one slit-image relay system are utilized to produce, on a film strip, direct displacement-time data which could not be obtained by any other means.

Electronic circuits are provided to time the release of the ballistic pendulums with the proper position of the film in the camera and to delay the opening of the shutter until just before the instant of initial impact.

Acknowledgment

The authors wish to thank R. E. Lewis, Physicist, Armour Research Foundation, and R. A. Einweck and C. R. Olson, Illinois Institute of Technology, for their help on this and other phases of the project.

The Navy's Training Film Production Program

And a Description of U. S. Naval Photographic Center Film Depository Facilities Available to Commercial Film and Television Agencies

By WILSON R. CRONENWETT and WILLIAM M. TIMMONS

The production of a motion picture is traced from the request stage through the Navy Film Board of Review, to production by either commercial contractor or the Navy Photographic Center. Film distribution is described, and also the special photographic services available to the film and television industries by the Naval Photographic Center's film depository.

THE NAVY'S film production program grows out of a need. The Navy has many training schools, special activities and, of course, the fleet. In all these places men must be trained efficiently and effectively in the skills and knowledges of Navy work. These are intensely practical needs.

In the past, the apprentice system has been an excellent method of meeting such needs. An inexperienced man worked alongside a trained man and gradually gained the same skills and knowledge through observation, active learning and correction of mistakes pointed out by the trained man. The apprentice system, however, was slow, could be used only for training a relatively small number of men. Necessary skills and knowledge in such highly technical and complex fields as electronics and fire control also proved the inadequacy of the apprentice system. The untrained man could not learn these complex skills and knowledge by observation. He could work beside the experienced man for many months without learning more than the superficial aspects of the work. Too much was hidden from direct view, or there was so much to view that one couldn't interpret it.

The training film, along with other aids and methods, has solved the training problem. It has many of the merits of the apprentice system, while at the same time permitting observation of those things which are normally hidden or which are cluttered up in a maze of detail. It is equally useful for teaching simple skills and techniques, and highly

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by LCDR Wilson R. Cronenwett, USN, Head, Motion Picture Branch, U.S. Naval Photographic Center, Anacostia, D.C., and Dr. William M. Timmons, Educational Adviser, Naval Photographic Center.

complex and technical ones. Moreover, it can effectively and rapidly teach many men simultaneously.

This was the need that had to be met during World War II. It was a big need and was not met all at once. The program grew. In the summer of 1941 the staff to meet the need consisted of one junior officer. By 1945 over one hundred officers were supervising the production of films. The Photo Science Laboratory had its own staff of writers, cameramen, editors, and technicians. There were about 30 training aids libraries and about 70 officers advising on film utilization. By early 1945 over 1000 motion pictures had been produced, as well as 2500 slide films. Close to a million prints had been distributed.

The films produced were good, bad, and indifferent. A surprising number were superior. All contributed to the practical job of training many officers and men in Navy skills and information. That they were generally good is due to a number of factors. The Navy leaned heavily on many small commercial producers who had developed considerable know-how in producing films for business and industry — practical films, often training films. The officers recruited as project supervisors came from two primary sources, the film industry and education. They, with the small commercial producers, made Navy films what they were.

The project supervisors with their diverse backgrounds were a source of ideas, methods and procedures, as well as of disagreements. They did not solve all the problems of how to make films that do the practical teaching job. But out of the ferment of the war-time group there came at least these results:

(1) A set of production procedures were worked out. (These are still used.)

(2) Production control procedures were developed. (These are still followed, with refinements.)

(3) Emphasis was placed on a new type of film, one designed to teach rather than to entertain.

We knew what we wanted but we did not know all the techniques of making films that teach. We still do not know, but we have made progress.

On the basis of this background, I want to indicate how the Navy's film needs are met today — what the program is today. There are three basic aspects to the program: production, distribution and procurement.

Production

The overall responsibility for film production in the Navy is in the hands of the Bureau of Aeronautics, Photographic Division. Production supervision and control are delegated to the U.S. Naval Photographic Center. All training films are therefore produced in their entirety at NPC or are produced commercially under the Center's supervision. In either case they are produced in close coordination with that part of the Navy desiring the film.

Although we have the usual administrative personnel to keep the entire program moving and an educational specialist to insure that each film does its intended teaching job, the key people on any production are two in number. One is the project supervisor, representing the Naval Photographic Center. The other is the technical adviser representing the Naval activity, school, Bureau or fleet unit wanting the film.

The project supervisor acts as the producer of his assigned projects. He may be responsible for as many as twenty projects at one time. He is responsible for planning, scheduling and supervising all except purely technical aspects of his projects from initial request to final acceptance of the training film. He must make sure that each of his films does the intended teaching job, is right as a motion picture, and is made within the allotted budget. He must judge the work of script writer, graphics

specialist, camera man, director, editor, animators, sound technicians and processing technicians. Naturally he leans on others to the extent needed, but his is the final responsibility.

The technical adviser is an expert in the content of the film. His basic responsibility is to make sure that the script and the resulting film are technically accurate and technically complete in all details. In addition, he must make sure that incidental things shown are right, that approved safety procedures are followed, that all clothing is properly worn, that security regulations are followed in what is shown, and that even little things like haircuts are strictly Navy.

The training film which these two individuals, project supervisor and technical adviser, work on may be any one of several types: motion picture, photographic report, public information film, slide film or filmagraph. While this classification may sound illogical, the terms have grown in response to the Navy situation. Some of the terms are self-explanatory. Others need a word of explanation. A motion picture is any carefully planned, complete motion picture production, in live action or animation, designed for training purposes. A film on *How to Get Usable Motion Picture Footage* falls into this category. A photographic report consists of motion picture coverage of an actual operation or activity put together in the best way possible to give general professional information to Naval personnel. A film showing an actual amphibious landing, covered photographically as well as circumstances permit, is a photographic report. A public information film is any motion picture telling the public about any part of the Navy. The slide film needs no definition. The filmagraph is essentially the same as a slide film except that the still pictures and the sound are put on motion picture stock, and the resulting film is projected on a standard sound motion picture projector. With careful planning, standard opticals and the use of popped-on or dissolved-on items or labels, camera trucks and simple pans, the filmagraph becomes a simulated motion picture. For certain kinds of content, where continuous motion is unimportant or where motion can be simulated by simple techniques, the filmagraph is an excellent, low-cost teaching film. We have used the filmagraph, for example, to show how to bend oak timbers and to explain the Navy's part in our Revolutionary War. In the Navy the filmagraph has largely replaced the slide film.

During the fiscal year now ending, of the films going into production 72% were motion pictures for specific training purposes, 10% were photographic reports for general training purposes, less than 2% were public information films, 16% were filmagraphs for specific training purposes, and none were slide films.

Thus, Navy production consists primarily of films for training. These films follow a general pattern of production. At the outset someone in the Navy has a training problem which he thinks can be solved by a film. In consultation with a representative of his parent Navy Bureau and an educational specialist from the Naval Photographic Center a decision is made that a film will or will not help solve the training problem. If it is agreed that a training film is desirable, they prepare a production outline. The production outline is a detailed analysis of who will see the film, what the audience already knows, what they should know or be able to do after seeing the film, the content to be included, the technical photographic specifications and shooting locations. In other words, the production outline includes the basic specifications on which the script and film will be based. Every effort is made at this stage to insure that only needed films are requested

and that the requested film will be a good teaching film.

The production outline is submitted to the Navy Film Production Board of Review. This board is made up of officers representing the training and fiscal parts of the Navy. They determine what training films are to be produced, the priority and the basic specifications for each film. For a film to be approved, the need must be justified, the plan must appear educationally sound and the project must represent a wise expenditure of public funds.

If the Navy Film Production Board of Review approves the project, the Bureau of Aeronautics assigns it to the Motion Picture Branch of the Naval Photographic Center for production. It becomes either an NPC production done entirely with NPC facilities or an NPC contract production done with the assistance of a commercial studio. Productions done entirely at the Center are normally those of the highest security classifications or those requiring shooting on location or intermittent photography that cannot be done efficiently by commercial studios.

Regardless of how the film is to be produced, the Photographic Center assigns the project to one of its twenty project supervisors. The requesting part of the Navy assigns a technical adviser. These two individuals supervise the preparation of a script. In all cases where art or animation is to be included in the film, the script includes a detailed storyboard. The resulting script must be more than technically correct. It must be capable of being produced at a reasonable expenditure of time and money. Expensive color is used only if it will contribute to the teaching quality of the film. The comparatively inexpensive filmagraph is used rather than the motion picture if the former will accomplish the film purpose as effectively. If a short film will do the job, no padding out is permitted. The script must be consistent with the specifications laid down by the Navy Film Production Board of Review, in accord with governmental policy and in good taste in all respects. It must lend itself to becoming a good film from the point of view of direction, photography, editing and sound. Above all it must be educationally valid.

It is on the educational side that we are making perhaps our most outstanding contribution. Emphasis on educational effectiveness is placed at the script stage. If the script is educationally sound and if the production follows the script, there will be little difficulty in making the resulting film educationally sound.

We shall not discuss our educational standards in detail here, but it may be helpful to indicate a few of the general principles followed. The script should make the learner aware of what is expected of him. The script should be carefully organized around the chief instructional values to be gained from the film, and this organization should be prominent in the presentation. The detailed development of every part of the film should be slow and clear in pictures and words, with primary emphasis on informative picturization. The treatment should be consistent with the film purpose and should generally be expository rather than telling a story or hanging on "gimmicks." The commentary should be simple, precise, brief, direct, dignified and closely integrated with the pictures. The introduction should be no longer than necessary to take the learners from where they are in information to the body of the film. The conclusion should reinforce the chief learnings. Obviously, the project supervisor must lean heavily on education and cost experts to make sure that he is meeting all his responsibilities at the script stage. In the same way the technical adviser must lean on other experts on fine points of the film content.

The script and storyboard must be approved by the superiors of both the project supervisor and the technical adviser.

Then the project goes into production, following the normal procedures of the industry. Because emphasis in directing, photographing, processing, editing and recording is on accomplishing the film purpose with integrity and authenticity, departures from the approved master script are never made for reasons of caprice, entertainment or aesthetics but only when changes are mandatory from a teaching point of view. The standards set by the industry on the technical aspects of photography, processing, sound and other film matters are followed by the Navy and the superiors of the project supervisor carefully check these aspects at interlock and acceptance screenings.

Distribution

The training aid to meet a specific training need has become a reality. To move this physical film to the many training schools, naval activities, reserve schools and the fleet, is a prime responsibility of Naval Film Distribution. Since the Navy is responsible for the production of all motion pictures for the Marine Corps, provision is also made for distribution to that part of the Naval Establishment. Operating under the Training Division of the Bureau of Naval Personnel, this activity has long been aware of the production progress of the motion picture. Following the Acceptance Screening of the picture at NPC, the film is screened before specialists at the Bureau of Personnel. These personnel have had pre-production information concerning the specific need for this particular training aid and have had conferences with the sponsoring Navy Bureau. The total number of film copies needed to perform the best training job is ascertained. Copies of such a highly specialized film as *African Trypanosomiasis* will not compare with the need for copies of a film on *Small Boat Disaster Prevention.* Normally, each major training film library will have at least one copy of every film made, and in the majority of instances, they will have numerous copies available to service the many users. With the recall of many reservists and the demothballing of ships, the major training film libraries will have many of the hundreds of copies made so that fleet units will be able to carry on immediate training with these aids. Within a month following the Korean outbreak, fleet demands swept the shelves of all extra copies of training films. Since the Navy film program was instituted, over 1,300,000 prints of training films have been distributed. The training potential of these prints is undeniable. To answer the question in your minds as to actual printing procedures, the work is divided between the printing facilities at NPC and commercial firms awarded printing contracts through competitive bidding.

The Navy feels that its distribution program must differ from present-day commercial practices. Since a 16mm print is relatively inexpensive, the emphasis is on making sufficient prints of a picture to insure that its information can be quickly disseminated, be readily available, and in such quantities that it will therefore satisfy the original need for the training medium. It is not unusual for print requirements to exceed 300 copies before a script is written or a camera grinds.

Procurement

This last of the three points deals with procurement practices of scripts and motion pictures not produced directly on the NPC sound stage, or by NPC crews.

Last year, over 100 motion pictures were completed for the Navy and the Marine Corps. Of these, 25% were service-produced at or by NPC. The remaining 75% were produced com-

mercially under our direct supervision, as shown above.

Almost daily, independent producers, large and small, self-styled professional cameramen, and small photographic facilities want to know whether they can make Navy pictures, whether they are large enough to produce for the Navy, what equipment they must buy to produce for the Navy, if the Navy will underwrite an initial production, and they ask a thousand other questions that might be considered laughable, were it not for the seriousness of their intent.

Navy motion pictures have been produced commercially by Hollywood's biggest firms, and by smaller producers in Chicago, Philadelphia, Atlanta, Detroit, Pittsburgh, New York, St. Paul and elsewhere.

There are six steps that must be taken by a producer wishing to make films for the Navy.

(1) In a letter in triplicate, addressed to the Chief, Bureau of Aeronautics (PH), Department of the Navy, Washington 25, D.C., give a résumé of your organization, including type and brief history, and state whether you are a corporation, a partnership, or sole proprietor.

(2) State that you are interested in Navy film production and the type you consider yourself best suited to handle. This information gives the procurement officer a better understanding of your capabilities and the kind of work on which to give you an opportunity to bid. If you are one of hundreds on a list, it isn't very practicable to ask you to bid on a film which will employ highly specialized types of medical photography, or other techniques in which you are not experienced. If the film is to be 100% animation, do you have an animation stand? Neither is it practicable, if you are located on the West Coast, to ask you to bid on a submarine film to be shot in New London, Conn.

(3) List your key personnel and give a brief outline of their experience in motion picture work.

(4) State the major types of facilities and equipment owned, or how made available to your company. There are no arbitrary rules about the size of your studio, nor will the Navy look askance at having sound recording done in a studio established for that purpose. However, if the major portion of your equipment is not owned, you are in effect not in the motion picture business.

(5) Enclose a balance sheet listing your assets and liabilities. The information will be held in strict confidence. Give the straight facts. The Navy's procurement analysts aren't to be fooled. The Navy does not pay in advance and the Government cannot sponsor you in business. The concern is whether you have the capabilities to complete an awarded contract. The emphasis is upon financial "soundness."

(6) Forward samples of pictures recently produced by your company, preferably educational or training films. The Navy wants to know what you can produce *now*, not what you produced several years ago.

The emphasis is on these basic factors: (1) experience (*and the kind of experience*); (2) key personnel and *their* experience; (3) physical facilities in terms of equipment owned; (4) financial stability; (5) the films you have produced and for whom; and (6) security clearance.

There are no geographical advantages, except that certain kinds of physical work naturally gravitate to the most convenient qualified source. But it is equally important to note, as all producers would emphatically agree, that national assignments involving considerable distances and location work have no such boundaries, that Eastern, Midwestern or Western companies work over a considerable geographical area.

The Navy takes considerable pride in its past and present procurement practices with commercial producers,

large and small. This association has been singularly marked by a fine spirit of mutual cooperation.

Conclusion

This has been a general view of the Navy's training film production program. It is a big program: 6091 films have been produced since the program was started back in 1941. It is an important program: the films have helped train thousands of officers and men. It has made at least a small imprint on civilian education and training: over 600 titles have been released to the public through the Office of Education, some of them selling as many as 1000 prints. The program owes much to the reserve officers who got it under way. It also owes much to the film industry. We are constantly trying to make it better — not for the sake of being better, but so that through training films more men can be trained better and faster to do jobs that have to be done.

Supplement

The Naval Photographic Center's film depository and its service to the film and television industry are apparent to everyone who is familiar with the Navy's cooperation and assistance in the production of such feature pictures as *Frogmen*, *Submarine Command*, *You're in the Navy Now*, the television documentary serials *Crusade in Europe* and *Crusade in the Pacific*, and in other current television shows and weekly newsreels. The film depository at NPC contains over 30 million feet of historical stock footage shot by Navy and Marine cameramen. In many instances there is duplicate material from other services. Non-classified sections of this storehouse of film and certain other services are available to commercial producers. The Navy, with the other services, has extended military cooperation or has collaborated on the production of commercial motion pictures for both theatrical and television release. Included under cooperation is the search for, and use of, official stock motion picture footage in connection with commercial pictures.

The clearinghouse for all requests for cooperation from any of the services, including the use of Navy-owned stock footage, is the Commercial Cooperation Unit, Pictorial Branch, Office of Public Information, Department of Defense. The wait for such help is not as long as the address mentioned, for the government understands that motion pictures, whether full-length features, documentaries or short subjects, and whether intended for theatrical or television release, are a vitally important and far-reaching means of sustaining public understanding of the military. The Commercial Cooperation Unit is geared to get applicants the help they need, and coordinates it through the Office of the Chief of Information — Department of Navy, which handles all further details. At this point, NPC enters the picture. The time lapse is surprisingly short. For instance, a request was made and filled within 48 hours for eight minutes of stock footage to accompany the TV appearance of CDR Gray, USN, on the program "We the People." The Naval Photographic Center film depository will arrange a convenient time for you or your representative to screen selected stock footage, or if the requirement is small will choose the material you need and forward it to you.

It is understandable that the amount of cooperation for stock footage or other services is directly proportional to the reach or scope of the production and its potential informational value. Requests for small lots of stock footage are filled as a public service. Either a fine-grain or a Kodachrome printing master is supplied. In the instances of stock footage for Hollywood major productions, arrangements are made to reimburse the Navy with a like amount of raw stock.

It would be well to mention here that an average of 80,000 ft of motion picture negative was coming to NPC from Navy sources all over the world each month before the outbreak of the Korean war. Since then, the shipments of original unprocessed negative stock has risen to 200,000 ft a month. In every case where security permits, a fine grain of selected footage of timely public interest is sent by the Department of Defense to the newsreel and television pool in New York. Duplicate negatives of this timely footage are then purchased by production organizations from a commercial printing laboratory in that area.

Your initial request for cooperation will bring a full set of instructions from the Department of Defense. The necessary, but small details, will not be given here. The most important facet of this situation is this consideration: if Navy footage is required, your production will be impracticable or impossible without official cooperation from the Navy. You will need to furnish a statement of your intent to produce and distribute for public consumption, a feature or short subject motion picture or television show based on some phase of the Navy. Your script will be included, and pertinent information as to the type of assistance required, i.e., stock footage, sound effects, technical advice, clearance to board Naval vessels or aircraft, or to borrow military equipment needed for authentic scenes, or actions.

In any event, security must not be compromised, the cooperation must not interfere with private enterprise, it must not interfere with military operations or the command concerned, and it must not cost the taxpayer or the government anything. An excellent illustration of such cooperation was the recent request by a major Hollywood studio wishing to photograph aviation activities aboard a carrier. No such ship was immediately available for use on the West Coast but the camera crews were able to board a flattop on its way to Korea and do their necessary photography before the ship reached Hawaii, at which point the commercial crews departed.

Discussion

M. R. Klein (Director of Army Film Library Services): Does the Navy instructor use a teaching technique in using the training film prior to showing the film? And also as a follow-up after the film is shown? In other words, are pertinent questions about the film prepared as part of the teaching technique in using your film?

W. R. Cronenwett: If I might comment as a former enlisted man, I saw a great many training films before I got into my present work. The Bureau of Personnel Training Division strives in every way to prepare a "package," so that the film or other visual aid is not the sole teaching medium, but exists as one of the teaching tools with which the Navy instructor works. We have made films for the trained and untrained instructor, who then knows — before he ever meets an audience — what he should do, how to bone up, the questions to ask, what questions he might be asked, and the answers. The film, the instructor's booklet, the other visual aids, the instructor — the human element — meld to train the fleet as best we can. I hope I've answered your question.

Howard Johnson (Federal Civil Defense Administration): Referring back to the production aspect of your paper, I think there are three points that require re-emphasis — three significant contributions of the Navy training film program. A good many of us will agree, I think, that the storyboard concept of planning a film is important in the documentary training film area; secondly, that most training films are one reel in length, which is important for curriculum integration, important for proper film utilization aboard ship or the shore station; and thirdly, that most Navy training films are documentary training films, in the best sense.

I would like to have you comment again on the emphasis of the storyboard planning for film production and its value.

LCDR Cronenwett: We find that in working with many people in the Navy

who do not have a film production concept that the use of a storyboard, with the script, will enable the requesting authority, and others who will pass upon the film before it gets to the fleet, to visualize the final product. As to film length, we feel that a film should be designed for a specific need. That is, if it needs to be a 3½-minute film, we'll make it; if a 13-minute film, we'll make that too. Too often a contract might call for a two-reel picture, and when 18½ minutes of film will do an adequate job, the film editor will needlessly lengthen the scenes to fill the two-reel requirement.

What was your third point, Mr. Johnson?

Mr. Johnson: Emphasis on the documentary . . . .

LCDR Cronenwett: Many of our films, as you can well imagine, are documentary in approach since many of them are photographic reports. In other words, we'll go out to cover an amphibious landing as best we can, without preplanning, because you can't always know what's going to happen. It would be as though we had planned to kine the show we saw on TV here this afternoon. Something invariably happens. May I say here, with pardonable pride in behalf of those people — officer and civilian — who have made training films for the Navy since 1942: twelve Navy films have won 16 national and international awards. I think these awards are based upon educationally sound, technically accurate, and technically well made motion pictures.

Nonsilver Photographic Processes

By THOMAS T. HILL

A number of nonsilver photographic, or light-sensitive systems such as those based on diazo dyes, have been used or proposed for specialized purposes. None of them, as yet, exhibits the sensitivity or the wide applicability of the silver process. This survey of the current status of these systems will discuss current limitations as well as possible future prospects with particular reference to the field of motion picture engineering.

DEFINED BROADLY, photography is a very widespread field. It includes all those systems by which an image can be made more or less permanent, an image resulting from an exposure to some type of light. Occasionally we see mention of new systems of photography and though they are often very promising, we are still working with the silver system of photography. So, the question arises, "Why haven't some of these other possibilities come into use?"

This paper will review some of these other possibilities, their advantages and their disadvantages in comparison with our current silver system, and discuss what we are likely to hear from them in the near future.

First, however, we must note that, while we grumble about the shortcomings of the silver emulsions which we now use, the necessity of processing them in solutions and finally the necessity of using them properly, they are really very versatile and set a high mark of accomplishment against which to compare the new possibilities. Examples of the wide versatility of silver-salt photography are easy to find, ranging from astronomical photography to photomicrography.

A discussion such as this one develops a new respect for the silver system, in that it is applicable to so many aspects of our work. On examination, we find that many of these newer light-sensitive systems are of narrow ranges of usefulness.

Photographic chemistry is but a branch of photochemistry, which studies all reactions caused by or accelerated by exposure to light. Among the many photochemical reactions are some which appear to be bases of new photographic systems, but which on further study are either so insensitive or have so limited an application that they are not really practical.

Among the possible light-sensitive systems of interest to us at present are the following (some of these, of course, are physical as well as chemical systems):

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diazo dyestuffs; diazo sulfonates; metal-diazonium system; dye bleach color systems; gelatin dichromate systems (and similar ones used in the graphic arts); thermography (such as the Minnesota Mining system); light-sensitive glasses (such as those of Corning); differentially hardened plastics and resins (such as bitumen, etc.); miscellaneous metals and metal salts (including those of lead, thallium, selenium, etc.); iron (such as those in blueprints); electrophotography (such as Xerography); platinum and palladium compounds (actually used in making prints from silver-salt negatives); and mercury salts.

Some of these processes or systems appeal to us because of either simplified processing, adaptability to varied temperatures, low costs or great stability in the final product. But, when balanced against the advantages of the silver process, they have all, up to now, fallen short, except for single specialized uses.

It is that aspect which will be discussed here in some detail. We should know something of what we can expect from these "new" systems and what we should not expect from them. In some cases, enthusiasm has been substituted for results, and we have to use some caution in assessing the reported examples of new proposals.

Evaluation of various systems:

Of course, not all of these nonsilver systems are new; many of them have been used for years for specific purposes. One of the most used is that based on the light-sensitivity of iron compounds which form a blue-colored salt upon exposure to light. We are all familiar with the blueprint, and many of us have used blueprint paper to make prints from still-camera negatives. The process, as you will recall, is very slow, requiring strong artificial light, or sunlight, and in most cases the papers in use are designed for high contrast rather than for continuous tone reproduction. As generally used, the results are not as permanent as silver images, although with proper treatment they can be made quite satisfactory.[1] But such special treatment eliminates two of the blueprint's advantages, low cost and simple processing. On these bases, together with the low sensitivity, we can eliminate this system from our consideration as a possible competitor to a silver compound in actual motion picture work.

In the field of plans and engineering drawings, the diazo print[2] is replacing the blueprint since it is a positive method, giving a positive copy of the original, and having greater contrast. Properly prepared, it is also more stable. Because of its ease and cheapness of processing and the low cost of the original material, the diazo system of photography is more promising than many others, and much effort has been put into it to make it more useful, and more of a competitor to the silver system. However, it has some important disadvantages from our present viewpoint, mainly very low sensitivity and a limited tone range. For black-and-white photography, the diazo system has another disadvantage in that there is no true dense opaque black available. The best blacks, so far, in this field are mixtures of dyes giving a very dark color which appears black on an opaque-base print, but does not have the density of a silver material.

The low sensitivity here is the problem which we meet again and again in studying the various nonsilver systems. In general, the advantage of the silver system is that it can be sensitized (in the meaning of that word used by emulsion chemists). That is, by adding small amounts of certain dyes and organic compounds together with sulfur compounds, the sensitivity of silver salts to light, including now the use of fluorescent materials, is greatly increased. But there is another great difference In silver photography, a latent image produced by a very small amount of

light is sufficient to give us the final results. This is because the working image is formed from that insignificant latent image by chemical reactions which themselves put energy into the system. In the case of diazotype, this is not the case, and all the energy needed to form the image must come from light energy. This is, of course, limited by the quanta of light available. In the case of the diazo system, which is a positive process, the light destroys the ability of the colorless dye precursor to couple to form the colored dye. Thus the areas receiving the most light, of course, give the least color on development, and those receiving no light give the densest color. But the energy necessary to make the change which produces the image is a result of energy applied to the system by the light, which makes the exposure. The chemical reactions taking place in the coupling reaction after exposure do not introduce chemical energy in the way that a silver photographic developer applies it.

Diazo materials have been experimented with as print material for photographic uses,[3] and even the simplicity of processing has not completely offset the low sensitivity and the short tone scale. Its success here has been in reproducing the sound track used in optical methods of sound recording.[4] Its ability to produce high resolution has been given as a great advantage here. However, the newer magnetic-tape methods of sound recording appear to be better at the present state of our knowledge.

As an example of what has been done with diazos, one fascinating attempt to improve this material, especially in its sensitivity, has been that worked out by the Philips organization of Holland and described in detail in the *Journal*.[4] Here, the low cost of the diazo material and its great resolving power are made use of, and the lack of sensitivity is partly overcome by combining with metal systems of mercury or cadmium, and by using silver and other materials in the "development." However, technical difficulties have yet to be completely overcome, and the process has not yet been put on the market. We will not take time here to discuss it in detail since it has already been well described in our *Journal*, as well as in other publications.[4,5]

A related system is that employing the diazo sulfonates,[2,6] which differ from the diazo system in that they produce a negative-type image such as we are familiar with from silver salts. The other interesting aspect of these compounds is that some of them are developable by the application of heat,[7] rather than by chemical reactions of separate developers. However, these compounds do not appear to be as sensitive even as the diazo compounds themselves, and there is great difficulty in trying to make papers or film materials with them which are stable enough to store or ship.

Brief mention should be made here of the dye-bleach color systems,[8] such as those used in such color photography methods as the early types of Gaspar color and others, which have been amply described in our own *Journal* and corollary literature. Here again we have the difficulty of sufficient sensitivity for original taking-film, but the materials have been applicable to making prints from negatives produced by using other processes.

Of course, several very old systems that have been used for reproduction purposes are those like the gelatin-dichromate[9] system, or its cousins, wherein there is a differential hardening of a gelatin or other colloidal layer by the action of light, which affects the ink-receptivity of the layer.[9a] These systems are the mainstay of the printing trades today and they are exceedingly useful in many ways, but they have a low sensitivity and require arc-light exposures, as well as freshly coated material prepared just before exposure. Recent

attempts have been made, some successfully, to utilize diazo-type compounds in printing-plate materials[10] in order to obtain presensitized plates which can be prepared and stored for some time before use. These still, however, require strong light sources and long exposures. All these systems require the use of a "screen" in order to reproduce tones, which limits their usefulness.

In somewhat the same field, fall the various differentially hardened plastics and resins,[11] and the old methods utilizing such materials as bitumen and pitch. As a matter of fact, some of the very old photographic processes antedating the daguerreotype utilized such systems[12]; however, they required exposures to sunlight in terms of hours, and did not give a very stable result.

An interesting variation of this idea is a recent report from a German experimenter[13] of the fact that the use of a tanning developer such as catechol, on a silver halide emulsion in gelatin will produce shadow detail in the gelatin itself in areas beyond those which receive the weakest silver image upon development. It is proposed to make use of this by dying the gelatin and then washing away the unhardened lesser-exposed areas with warm water, leaving a silver image, together with this dye-plus-gelatin image, which combines to make a denser negative, especially in the very weak shadow regions. This would, of course, require a special type of emulsion and additional special treatment which, though it appears to be capable of greater sensitivity than the silver methods normally used, requires extra care and treatment in processing which makes it difficult of application.

Salts of various heavy metals such as lead,[14] thallium,[15] selenium[16] and many others have been used to form photographic images, such as were also formed in an experiment during the late war by one military man who used the familiar trinitrotoluene or TNT to make a photographic image.[17] He did this by coating paper with a solution of TNT, drying it and exposing it to light. In all these cases the sensitivity so far appears to be very low, and no method of increasing the sensitivity has yet been reported.

One rather surprising nonsilver system has recently been proposed which is brought to mind by the use just mentioned for TNT. This is the use of explosive materials to form an image by the results of the explosion. In a recent report the use of nitrogen triiodide is described. This is a ticklish material which many of us used to use in schooldays for practical jokes; it will explode with great noise when slightly disturbed, even when tickled with a feather. In this case, the light falling on it through a lens is sufficient to set off an explosion, and an image is left on the support, burned in by the explosion.[18]

The light-sensitive glasses developed by the Corning Glass Works[19] are of interest, especially as they will give some colors as well as black-and-white images, but they are not practical for motion picture engineering use because of the fragility of the base material, the special processing (requiring very high temperature fusing) and other difficulties, which we understand also include a low sensitivity. The colors obtained are not "natural" colors as in Kodachrome, etc.

On the other hand, quite interesting advances have been made with various processes of electro-photography, such as have been developed at the Battelle Memorial Institute in connection with the work of Haloid Co. under the name of Xerography.[20] Further work on this has been done at the Signal Corps Engineering Laboratories (Squier Signal Corps Laboratory) at Fort Monmouth, N. J., and reported in the recent literature.[21] They appear to have overcome the early difficulties of poor tone-scale

reproduction, and we have seen portraits made by this process which had fairly good quality.

The process basically involves the "sensitizing" of a prepared selenium plate by giving it an electrostatic charge. Upon exposure to light, in our case to an image, the resistance of the plate drops in the higher exposure regions, so that the charge there is less. Development consists of dusting on a dry powder which clings to the areas still holding the most electrostatic charge. This powder image may be fused to permanence by heat, or transferred to another paper support and then fused. Three to five seconds in a photographic dry mounting press will do the trick. The plate itself can then be cleaned and re-used for another picture. The great advantage here is the speed of processing and the fact that it is an all-dry system without water solutions. However, the manipulation by the operator including the preparation of the plate just before exposure, whether of selenium or of phosphors[22] (both of which systems are used), is quite difficult and delicate, and a high-tension electrical system is necessary to utilize this method. It gives a direct-positive result, and does not as yet appear to be applicable to a negative-to-positive system. However, a great deal of work is being done on it for the various applications such as photocopy work, special Air Corps cameras, and even for X-ray use,[23] and to prepare lithographic printing plates.[24]

Another interesting process announced fairly recently, is that referred to as thermography,[25] exemplified by the heat copying process, recently announced by the Minnesota Mining & Mfg. Co. In this process, called Thermofax, the image is formed by an infrared or heat exposure which melts a waxy material where inked areas concentrate the heat, and the resulting image on a special paper is both a positive and a negative. This may be rather confusing, but the fact is that as a result of this exposure you get a print on a semi-opaque paper which by reflected light looks like a positive, since the exposed areas are darker than the chalky blue-white background (of the example we saw). However, when viewed by transmitted light, those exposed areas become a transparent light blue against an opaque whitish-blue background, and form a negative image which can be used to make prints by usual contact printing methods on silver-salt materials. This appears to have interesting applications for office photocopy use, and this is the first commercial application being worked on. However, it requires exposure to heat, or infrared rather than visible light rays. It does not appear to have a great deal of tone range, and it appears to be very slow, as with so many of these nonsilver systems; therefore, as presently described, it does not appear to have any application at all for our present purposes.

Conclusions

Having now discussed and described some of these proposed light-sensitive systems, the question is, Where do we go from here?

It would seem that each of these systems, which we have so briefly examined, has at least one great shortcoming in comparison to the silver-salt process we are so familiar with. They all appear to have a low sensitivity to light. Many of them appear to have a poor tone range, and some of them seem to require even more complicated processing techniques to produce the final image.

It would therefore seem that, as presently developed, none of these systems has any immediate direct application to motion picture photography, that is in preparing either the positive print or the negative film from which the positive is printed. There are a few cases, such as the Philips diazonium system, which appear to have some promise for making prints. This is also true of

some of the dye-bleach color systems such as early Gaspar color. In a few cases the low sensitivity is not so important. But where the sensitivity has been even somewhat increased, the cost of the material is no longer low, and therefore such a system is less competitive with the silver-salt process than it was originally.

Of course, in auxiliary aspects of our work, some of the nonsilver processes can be used but not in a direct, motion-picture-taking application.

But what of the future? Can some of these processes come up to the overall advantages of the silver process? A close study of the literature in a number of these cases, and first-hand experience with a number of these processes in the laboratory, indicate that they have a long way to go before any of them could successfully challenge silver for more than a small part of silver's great range of usefulness. For example, we have had an opportunity to watch an investigation recently of claims to a new process by which the sensitivity of a diazo dye process was to be increased to equal that of silver materials. When it was finally boiled down it was found that the sensitization simply did not work. Applied to textiles, this special type of diazo process was quite practical, but it required terrifically long exposures or exposures to extremely bright light at very close range, and it required exposure of the material while wet. So, another hopeful method of speeding up one of the nonsilver processes went by the board.

In general, our present conclusion must be that none of these other processes is likely to become competitive to the silver process in the near future, for our purposes. In some specialized fields, such as photocopy work, and other cases where high exposure speed and good tone range are not necessary, there is great hope that some of these methods will give results equal to that given by silver emulsions at lower costs and with simpler processing techniques, but with the very high requirements of the motion picture art, we of this group cannot expect much from any of these "new" systems for a long time to come.

Therefore our major efforts at present should be expended on improving the processing technique of the silver process in order to simplify it, and lower the cost. Some of these methods appear to be very promising, such as the stabilization techniques to replace the fixing and washing stages of normal silver processing. The use of higher temperatures, spray processing procedures and other improvements in this aspect, will decrease some of the few disadvantages of our familiar and very successful silver light-sensitive process.

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Discussion

Wm. H. Offenhauser (Consultant): In among some old film clips that I had a number of years ago, there was a strip of diazo process film that was printed in France. The picture was *Dreyfus.* I lost its history from that point on. I wonder if you can tell us why the thing died or why it might have started at all.

Thomas T. Hill: There was a lot of promise in that process. Of course, the diazo system is promising because you have colors there and they thought they could make use of it. Also it's nongelatin. Actually the sensitive material is cast right into the base, whether it's a celluloid base or a cellophane base. Most of the sound-track methods were on a cellophane base like the Philips diazonium process. One of the drawbacks was that you did not have the dimensional stability and the overall usefulness of your prints running as many hundreds or thousands of times as does a good print from material we use now.

Another trouble was that these diazo dyes were not as light stable, and after projection a few dozen times the image began to fade. It's very difficult to get good fixing with diazo materials — so nothing intensifies or darkens, and so that the dyes do not fade. That seems to be why that thing has fallen by the wayside up to now. There's still enough promise, I think, to continue with it, but it isn't as good as was hoped for in the beginning.

Anon: Is there anything in the literature that would indicate the problems of sound recording on these nonsilver media?

Mr. Hill: That was one of the applications that the Philips diazonium process was aimed at, because of its terrifically high resolution — they thought they could get a better sound track. But when I talked to the men who had worked on it in this country they told me that they had found several things wrong with the thing as developed in Holland and sent it back for further research. One of the troubles was that they spent all of their time working on a material on a cellophane base. Because of the very thinness of the material they could put a big reel of film with sound track on a very small area, but the people in this country pointed out that the dimensional stability of the cellophane wasn't up to what we're used to in the motion picture industry and it just simply wouldn't work for that reason.

The other thing was, of course, the mercury involved a health hazard which they apparently hadn't realized. So it has gone back to Holland for work with the cadmium aspect of the system and Dr. Jamieson of the Philips Laboratories in Irvington-on-Hudson, New York, told me recently that there's some promise that they'll come back again with better results for that specific purpose on sound track.

Anon: So the summary is probably that Eastman Kodak and du Pont and Ansco can continue to make film for a little while?

Mr. Hill: For quite a while.

Anon: Until the magnetic boys catch up with them.

Mr. Offenhauser: I'd like to bring in a little more history at this point. Just before World War II when I was with John Maurer we were working with a wide-range silver film master record recording system for frequency modulation broadcasting. We used Class A push-pull, direct-positive recording on yellow-dyed silver film with galvanometers that peaked at 22 kc and with a film speed of 60 ft per min. The direct-positive was printed in diazo material by Agfa-Ansco at Binghamton.

We made prints on diazo material and the objective at that time was to use the prints from these records for FM stations as transcription record material on account of the fact that we found very low distortion levels in the diazo prints from the silver originals. I mention this as a matter of history.

Mauro Zambuto (Scalera Films, Rome, Italy): One advantage of those diazo films was that they scratched less in some aspects of them. In connection with the sound-track use of the diazo materials, I wish to say that I also had some experience with that particular film that was made in France, and incidentally it was *Dreyfus.* That was back in 1939. Now, there was one major problem at the time due to the

fact that the diazo materials never seemed to reach a very high density. So in this particular instance, the most trouble they had was with the signal-to-noise ratio. I would like to know if in the new experiments anything better has been achieved.

Mr. Hill: There has been a good deal of work done on that aspect simply for the office copying use of diazo on paper in trying to get a better and more opaque black, and I'm sure that some of those things have given us combinations of dyes which are better than we had, say, twelve or thirteen years ago. It is that total density that they're trying to improve, but as with any of the dyes, where you have a black dyestuff for cloth or any other purpose, you really have a very dark color rather than a true black. In the same way with the diazo coupling, and as I mentioned before, there is a faint fading going on so that when you've got a total density that's still a little less than you want and then it starts to fade, you've still got trouble. But I'm sure that some of the dyes that have been worked out in the past four or five years are much better than they've had before.

Mr. Zambuto: Could you give us any figure as to the amount of signal-to-noise ratio that was achieved?

Mr. Hill: In that case I can't. The stuff I have seen has been on paper materials. We've been involved in the basic chemicals rather than in the application, so that we don't have that part of it going through our lab. But we do have the basic chemicals and their coupling to get a black, black as possible on paper.

Mr. Offenhauser: As I remember it, we had something like 60-db signal-to-noise ratio and something less than 2% harmonic distortion. The figures can be obtained, I believe, from Andre Schoen in Binghamton; he has the logs and test data. We would never have contemplated using these materials for FM transmission unless the performance was that good or better. We used blue-sensitive photocells with matching dyes; these latter were peaked in the same general spectral range. We tried many dyes and cells experimentally; the blue combination proved to have the best performance at the time.

72d Semiannual Convention

Hotel Statler, Washington, D.C.
October 6–10

Wheels have been turning for the Washington Convention ever since the Editorial-Papers Committee Meeting at Hollywood last October. In addition to specific plans for last April's Chicago Convention, general plans were laid for a year ahead and Joe Aiken, Papers Committee Vice-Chairman for Washington, D.C., was welcomed and was promised cooperation from all present in his job as Program Chairman.

The 72d Convention, even in its present, embryonic form, is proving again the worth of the practices and procedure worked out over the past few years by Papers Committee Chairman Ed Seeley. It used to be that the Papers Committee Chairman organized the technical papers program on his own primary responsibility and also almost completely by his own efforts. Not only was this a great burden on the same individual twice a year but also it was apparently less effective than having someone in the convention city responsible for the program; so Ed Seeley set up the title and function of Program Chairman. The Program Chairman is the Papers Committee Vice-Chairman in the convention city. General advice and carry-over information go to the Program Chairman from the Papers Committee Chairman and also from the Program Chairman of the previous convention. The Society's headquarter's staff assists only by trying to assure mutual understanding by all concerned and by channeling suggestions which come from divers members. The Editorial Vice-President is responsible to the Society's Board of Governors for the function of the Papers Committee and so, also, for the technical sessions of conventions. The Editorial Vice-President's convention role, as most recently exemplified by John Frayne, is that of being helpful only when called upon specifically and by using his special and good offices to obtain special papers or initiate plans for particular sessions.

Leads, suggestions, or finished papers may originate with any interested person — but all paper possibilities should be channeled through a Papers Committee member. The Papers Committee Vice-Chairman in the area should be kept informed of the development. Papers Committee members and vice-chairmen are responsible for initiative in their respective companies or areas.

For the Washington Convention, Joe Aiken will also be Local Arrangements Chairman, assisted by a roster of Washington folks who were nearly all appointed at a meeting in Washington on May 29 when Convention Vice-President Bill Kunzmann was in Washington to make convention plans and commitments. The list of those responsible for the many duties and functions will be published in the August *Journal* — but this does not mean that there is no room for more helpers or suggestions, particularly for research, techniques or new products manuscripts. These should preferably be channeled through the Papers Committee Vice-Chairman or member nearest you. The complete Papers Committee is:

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M. G. Townsley, Bell & Howell, 7100 McCormick Rd., Chicago 45, Ill.

Three special sessions have long been scheduled for the Washington Convention: (1) an international symposium on high-speed photography for as much as two full days' sessions, some or all of them concurrent with other sessions; (2) a session on magnetic striping of film; and (3) a session on maintenance of 16mm equipment. More details about these and other sessions will be given in next month's *Journal*. On August 6 all members will be sent the Advance Notice of the Convention. This is the usual folded postal mailer which gives the schedule of sessions and includes a tear-off postal for making hotel reservations.

Engineering Activities

Status of Proposed Standards: In the past year or so quite a few proposed standards have been published for trial and criticism. The status of these is outlined below to bring all concerned up to date.—*Henry Kogel*, Staff Engineer.

Title	PH 22	Date pub.	Status
Cutting and Perforating Dimensions for 35mm Motion Picture Film — Alternate Standards for Either Positive or Negative Raw Stock	.1	9/51	Approved by Standards Committee. Now out to letter ballot of ASA Sectional Committee PH22.
Emulsion and Sound Record Positions in Camera for 16mm Sound Motion Picture Film	.15	12/51	Further revisions have been proposed which are now being considered by the 16 and 8mm Committee.
Emulsion and Sound Record Positions in Projector for Direct Front Projection of 16mm Sound Motion Picture Film	.16	12/51	
Screen Brightness for 35mm Motion Picture	.39	5/52	Trial period ends Aug. 15. No Adverse comments received as yet.
A & B Windings of 16mm Raw Stock Film with Perforations Along One Edge	.75	1/51	Adverse comments were received. Several new drafts have since been proposed by 16 and 8mm Committee to resolve the differences. The latest is now going out to letter ballot of the 16 and 8mm Committee.
Edge Number 16mm Motion Picture	.83	1/51	Approved by PH22. Must next be reviewed by SMPTE Board of Governors for Sponsor approval.
Dimensions for Projection Lamps Medium Prefocus Ring Double-Contact Base-Up Type for 16mm and 8mm Motion Picture Projectors	.84	2/51	Approved by Standards Committee. Now out to letter ballot of ASA Sectional Committee PH22.
Dimensions for Projection Lamps Medium Prefocus Base-Down Type for 16mm and 8mm Motion Picture Projectors	.85	2/51	
Enlargement Ratio for 16mm to 35mm Optical Printing	.92	1/52	

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal*.

Letters to the Editor

Re: Three-Dimensional Motion Picture Nomenclature

I have read with great interest Major Bernier's article on "Three-Dimensional Applications" which appeared in the *Jour. SMPTE, 56:* 599–612, June 1951.

Major Bernier is to be congratulated on his paper and also on the interesting experimental work which he and his unit are conducting. The writer would, nevertheless, like to draw attention to a few points in the paper in connection with which there seems to be some confusion.

On page 599 in the *Journal*, reference is made to "the composite or lenticulated system," but just what Major Bernier is endeavoring to convey by this terminology is not clear. There are three main groups of processes (embracing hundreds of different modes of application) which might conceivably, but should not, be referred to in this way. These three groups comprise: (1) integral processes, which had their genesis in the idea conceived by Gabriel Lippman and disclosed by him in 1908 (*Compt. rend., 146:* 446–51); (2) parallax stereogram processes, all of which are derived from the principle described in Frederic Ive's U.S. Pat. 725,567 (application date, Sept. 25, 1902); and (3) parallax panoramagram processes, which depend on the principle of C. W. Kanolt, described by him in his U.S. Pat. 1,260,682 (application date, Jan. 16, 1915).

The problems involved in producing spherically lenticulated film as proposed by Lippman were not solved during the inventor's lifetime, but the earliest practical process (for still photography) employing a cylindrically lenticulated screen with which the writer is acquainted was described by Walter Hess in 1911 in his Brit. Pat. 13,034.

The most important of Dr. Herbert Ive's ideas relating to stereo kinematography are those embodied in Brit. Pat. 348,118 (application date, Feb. 7, 1930) and his corresponding U.S. application (convention date, Feb. 9, 1929). Very many other processes involving the use of line or lenticular grids, for both still and motion pictures, were evolved between 1911 and 1929.

In discussing, on page 601 of the *Journal*, the various factors contributing to depth perception, Major Bernier has again departed from accepted terminology, and this may be confusing to some with limited knowledge of the subject. For example, factor No. 4, in Major Bernier's list should read "Accommodation," not "Focus reaction," and factor No. 6 should read "Binocular vision," not "Stereoscopic vision."

The word "stereoscopic" means (freely translated from the Greek), of course, "seeing solid" or, as we are accustomed to say, three-dimensionally or stereoscopically. Accordingly, the term "stereoscopic vision" applies to the net effect resulting from the various contributory factors. In compiling a "short list" of these factors, it is, in the writer's opinion, difficult to improve on the custom of dividing them into two groups: (1) monocular factors; and (2) binocular factors. In the first group the chief factors are accommodation and perspective, and in the second group we have parallax and the faculty of convergence. There are numerous subsidiary factors, some of which are mentioned by Major Bernier.

Referring to the comments in the second paragraph of page 601, whilst it is, of course, true that accommodation becomes of decreasing importance with increasing distance of the object, neither this fact nor any other warrants definition of a distance of 20 ft as "optical infinity."

The reasoning on the next paragraph of the paper is based on a fallacy. It can best be demonstrated experimentally that the faculty of accommodation is stimulated practically always when one is watching projected motion pictures. The apparent size of the image is no less important than the distance of the screen in determining the degree of stimulation. Let us suppose, for example, that the film being projected depicts an object moving toward or away from the observer so that it is progressively either increasing or decreasing in size. If the object depicted is a familiar one, and the apparent size of the image corre-

sponds to a distance within the normal range of accommodation, the eye will attempt to accommodate for that distance. This momentarily throws the screen out of focus, so the eye then re-accommodates for the plane of the screen. If, by that time the image of the object — assumed to be still moving — is at a different "apparent" distance within the range of accommodation, the eye will attempt to accommodate for the new distance, thereby again throwing the screen out of focus. This cycle of events recurs with great rapidity, and is sometimes the cause of headaches amongst elderly cinema patrons, whose ocular sensory organs and muscles are, naturally, less responsive than those of younger people.

With regard to the main subject discussed in Major Bernier's paper, namely, the development of alternate-frame stereo techniques, it is, perhaps, worth drawing attention to the fact that the majority of the basic problems involved were investigated in England by the writer, Edwin Wright and others several years ago. Work on such processes has been abandoned by most workers in this country, mainly owing to recognition of the fact that the disadvantages resulting from "time parallax" are inherent in all alternate-frame systems.

There are several known methods of overcoming the flicker problem, that developed by Wright being as satisfactory as any; the writer considers it preferable to the use of the more complex Morgana shuttle movement. A description of Wright's method is given in the writer's book, *Stereoptics — An Introduction*, Macdonald & Co. Ltd., London, 1951.

Major Bernier's comments concerning the flicker problem are made somewhat difficult to follow by this use of phrases such as "a flicker frequency of 72 frames/sec, or 36 frames/sec per eye," which do not really convey what the author intended, as the important matter is the number of *occultations* per second rather than the number of frames.

To understand the nature of the flicker problem it is essential to appreciate that with any projection system, whether stereoscopic or planoscopic, the rate of flicker per second is equal to the number of times per second that light is occulted from each eye. Thus, in ordinary planoscopic projection, the flicker rate is equal to the product of the number of frames projected per second and the number of blades in the shutter. When projecting planoscopically at 16 frames per second, for example, the flicker rate is 32 or 48 per second according to whether a 2-blade or 3-blade shutter is employed. In neither of these two cases is flicker perceptible to the eye, so the term "flicker" is really a misnomer in such instances. It is readily demonstrable that the minimum rate of occultation necessary to prevent the occurrence of objectionable flicker is about 24 frames/sec, this rate being achieved at a projection speed of 12 frames/sec with a 2-blade shutter or 8 frames/sec with a 3-blade shutter.

Now, with stereoscopic systems of the type in question, light is occulted from each eye every time a picture intended for the other eye is projected. This means that in addition to the faster, imperceptible occultations produced by the shutter, there occur occultations at a slower rate numerically equal to one-half the number of frames projected per second. Accordingly, in order to provide the necessary minimum of 24 occultations per second for each eye, a projection rate of 48 frames per second must be adopted, regardless of the number of blades in the shutter. As this is generally impractical, it becomes necessary to adopt some arrangement such as those used by Wright and Major Bernier. The writer ventures, nevertheless, to express the opinion that such arrangements are not really worth while owing to the facts that "time parallax" errors are still present and that the apparatus is somewhat complex. He would like, in conclusion, to draw attention to the new single-film polarized light process some particulars of which are given in his paper "Stereoscopy in the Telekinema and in the Future," which appeared in *British Kinematography, 18, No. 6:* 172–181, June 1951. This would appear to be the most satisfactory polarized light process so far developed.

August 30, 1951

L. Dudley
Odeon Theatre
Kensington High St.
London, W. 8,
England

Reply to the Letter Above

The recent letter by Mr. L. Dudley, director of the Laboratory, Odeon Theatre, London, indicates his confusion in reading my paper "Three-Dimensional Motion Picture Applications," published in the June 1951 issue of this *Journal*. I would therefore like the opportunity to set forth in more detail the explanation of certain phraseology and certain technical aspects with which Mr. Dudley was confused.

He points out that "there are three main groups of processes, which might conceivably, but should not be referred to as the "composite or lenticulated system," as I did on page 599 in the *Journal*. Although he listed the three main groups, he didn't give any indication of how that type of three-dimensional photography could intelligently be referred to. As I see it, each of the groups has one thing in common: namely, that a viewing device on or near the eyes is not needed to vision the three-dimensional results. Each depends on a medium near the picture surface to selectively direct the proper views of the subject to their respective eyes. To produce a stereoscopic vision in the brain, this medium is dependent, in all cases, on one basic fact, that the eyes are displaced. Since the groups, as Mr. Dudley refers to them, are therefore more or less related, there should, in my opinion, be some definite means of referring to them.

I could not find anything in the literature which seemed to suitably express this phase of stereoscopy, and as a result chose to refer to the latest refinements of it as the "composite or lenticulated" system. As to the source of the expression "composite," it appears in the reference book *Medical Physics*, edited by Otto Glasser, Ph.D., Year Book Publishers, Inc., Chicago, 1944–1950, on page 1326 in a treatise on three-dimensional photography. The article under a paragraph heading "Trivision" reads "Early in 1941, the Winnek Laboratory introduced a new process of composite stereography, now called "Trivision." Composite photography, as defined in Webster's New International Dictionary, means a photograph or portrait made by a combination, or *blending* of several distinct photographs, either made one over the other, or made on one print from a number of negatives." This, in my opinion, comes very close to describing the condition that exists in the present picture emulsion of the French "Portrait en Relief," the British "Deep Pictures," or the American "Trivision," and other trade processes, all of which stem from the pioneering efforts of H. E. Ives (1902), Lippman (1908) and, of course, Berthier (1896).

These refinements of which I speak, consist in segregating and resolving (within limits), by means of a lenticulated surface in front of the emulsion, a continuous changing view, or an infinite number of views of the subject. Thus, when the composite picture is viewed through the same or an identical lenticulated surface, left and right views are selectively projected to their respective eyes. Reasonable freedom of movement of the viewing position either laterally or perpendicularly to the picture is possible, because any two views of the composite, within the angle of coverage of the lenticulation formula employed, will always be a left and right view of the subject, and will be directed to the left and right eyes, respectively.

The reason, thus, that I referred to this phase of three-dimensional photography as the "composite" or "lenticulated" system is because, in my opinion, this phraseology most adequately describes this process of three-dimensional photography which in turn has enjoyed limited recent popularity as a result of a more efficient combined use of these two basic features.

I chose to use "Focus reaction" rather than "accommodation" in listing my interpretation of the basic factors of depth perception, because it seemed to me that this expression would be more easily understood by the layman, rather than the more technical expression "accommodation," used almost exclusively in ophthalmic practices. Also, I intended to imply that it is not, in my opinion, the difference in the character of the focus of objects which notifies the brain of their relative positions in space, but on the other hand the reaction due to the tensing of the ciliary muscles.

In connection with my use of "Stereoscopic vision" as the sixth factor, instead

of the commonly used phrase "Binocular vision," I reasoned that it is possible to use "two eyes" in certain cases, but not to be able to see stereoscopically. For example, the conventional binocular microscope has two oculars, but only one objective; and thus when using such a microscope binocularly, one does not see stereoscopically. This is also true of some binocular viewers for single Kodachrome transparencies; also when viewing any single photograph or painting binocularly the subject matter cannot be seen stereoscopically. Thus it would seem that the only requirement to actually view subject matter stereoscopically is to change the angle of convergence of the eyes for different planes of depth.

We view present two-dimensional color motion pictures on the screen with both eyes, or binocularly, but we cannot see the subject matter stereoscopically because of the absence of the requirement to change convergence for different planes of depth. This would be a case where all the factors that Mr. Dudley would like listed could be activated, but we still could not see the subject matter stereoscopically. This is the reason I chose to use "Stereoscopic vision" rather than "Binocular vision" as the sixth factor of depth perception.

It seems to me that his reasoning "that stereoscopic vision is the net result of the various contributing factors" is based on a fallacy. Stereoscopic vision is achieved in the "Anti-Aircraft stereoscopic height finder" without any of the contributing factors Mr. Dudley mentions, except the "faculty of convergence." The determination of the slant range of aircraft in this case, depends solely on this factor, and as I chose to say "Stereoscopic vision."

In connection with Mr. Dudley's objection to my use of the expression "Optical infinity," and that I indicated that it could be considered as 20 ft, I would like to point out that this is a common expression in the field of ophthalmology and optometry, and to all American trained optometrists the expression immediately suggests 20 ft, since this theory for many years has been and is being taught in American colleges and universities (see textbook *Outline of Optometry* by I. M. Borish, page 36, Sec. 8 A1, or *Physiological Optics* by W. D. Zoethout, 4th ed., Professional Press, Inc., Chicago, 1947, page 38, paragraph titled "Principal Foci.")

The next paragraph of my paper, contrary to Mr. Dudley's opinion, is based on the fact that there is a direct relationship between accommodation and convergence. Namely, that when converged at a certain distance, the eyes in a normal individual will also automatically focus for that distance and vice versa. This relationship is thoroughly discussed on pages 431 and 432 of A. C. Hardy and F. H. Perrin's *The Principles of Optics*, first edition, ninth impression, Camera Craft Publishing, San Francisco, 1943. Thus, if what Mr. Dudley says is true it would seem to me that referring to the examples he gives of a film depicting objects moving toward or away from the observer, that the eyes would also want to change convergence. If they change their convergence to follow the apparent position of this moving object, the result would be double imaging. This also should occur "with great rapidity," but I don't believe it does. I maintain, as indicated in my paper, that as long as subject matter in the three-dimensional motion picture appears no closer than 6 or 8 ft from the observer, accommodation errors will not result. I cannot agree with Mr. Dudley on the cause of headaches amongst some older people who go to the movies, since it is common knowledge in ophthalmic practice that they lose their power of accommodation as a result of progressive hardening of the crystalline lens as they grow older. This would indicate to me that as long as they were wearing glasses corrected for the screen distance, the subject matter on the screen would remain always in focus. Therefore it is interesting to note that when this be the case, especially with three-dimensional motion pictures, they will see subject matter clearly even when required to converge on three-dimensional screen objects, which could conceivably appear as close as two or three feet in front of their faces. As an added prediction, they will quickly realize that for such a phenomenon, they will not need to "peer" through their "bifocals."

I prefer not to disclose as yet what improvements have been made in connection with the alternate frame system. However, I would like to assure Mr. Dudley that the

"time parallax" problem has been completely solved, and that the alternate frame principle with the latest modifications shows promise, in my opinion, of being the most all-around satisfactory stereoscopic motion picture method to date.

In regard to my use of the phrase "a flicker frequency of 72 frames/sec, or 36 frames/sec per eye," I would like to clear up Mr. Dudley's apparent confusion in respect to the action of the Morgana movement. This movement, I made quite clear in my paper, actually transports frames of film in and out of the film gate at the rate of 72 frames/sec. This rate of frame transport is, therefore, exactly coincident with the shutter-blade rate, and therefore is also identical to the total "occultation" rate. Thus the right frames, for example, are transported in and out of the film at the rate of 36 frames/sec, which also equals the "occultation" rate for that eye, per second. Since, then, the actual framing rate is also equal to the flicker rate, I believe it reasonable to express the flicker frequency in terms of "frames per second." As I pointed out in my paper, since every third transport consists in moving a "frame backwards" out of the gate, the net result is a "progression of the film through the projector at standard sound speed."

Again I cannot agree with Mr. Dudley's contention that "the minimum rate of occultation necessary to prevent the occurrence of objectionable flicker is about 24 per second." If this were true it would not be necessary to use a two-bladed shutter in standard theater-type projectors, which in turn doubles the occultation rate with respect to the "24/sec" frame rate.

When the film *3 D Motion Pictures* was screened at the SMPTE 1951 Spring Convention, some may recall that there still remained some flicker. This was due to the comparatively slow flicker frequency of 36 frames/sec per eye. This frequency was somewhat objectionable, and to bring it up to present standards, improvements had to be made. A new projector, which will incorporate important changes will be ready to demonstrate in the near future.

November 14, 1951

Robert V. Bernier, Major, U.S.A.F.,
Hq. Wright Air Development Center,
Box 7145, Area B,
Wright-Patterson AFB,
Dayton, Ohio

Obituary

Charles Ross died in June at the age of 63. He was President and sole owner of Charles Ross, Inc., a business which he started 30 years ago.

He began working for motion picture studios in New York City when a boy, one of his early employers having been the Biograph Studios. He was an electrician and he gradually built up stocks of everything from cables to equipment which eventually included every type of lighting or grip equipment for motion picture production.

He was educated in the New York public schools and some time after he had begun his business he and Pete Mole discovered in mutual reminiscing that they had grown up in the same New York City neighborhood and gone to the same schools without then being acquainted. Charles Ross, Inc., has now for long been sole eastern agents for Mole-Richardson equipment. The firm's headquarters at 333 W. 52 St., New York 19, N.Y., is in the same neighborhood where Mr. Ross had offices and warehouse during his decades in business.

Besides being an Active Member of this Society, Charles Ross was a member of Motion Picture Pioneers, Theatre Equipment and Supply Manufacturers' Association, Stage Employees' Local #1 of the IATSE and Motion Picture Studio Mechanics Local #52 of the IATSE.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1952 MEMBERSHIP DIRECTORY.
Honorary (H) Fellow (F) Active (M) Associate (A) Student (S)

Allen, James M., Cinematographer, Sandia Corp. **Mail:** 223 La Merced Ave., Albuquerque, N.M. (A)

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Yuskaitis, Robert J., Owner, Eagle Laboratory, 1732 N. Orchard St., Chicago 54, Ill. (**A**)

CHANGES IN GRADE

Atkinson, R. B., (**A**) to (**M**)
Beard, D. M., (**A**) to (**M**)
Bernard, H., (**S**) to (**A**)
Blaney, Dorothy, (**A**) to (**M**)
Flory, John, (**A**) to (**M**)
Pfahler, R. A., (**A**) to (**M**)
Riley, L. W., (**A**) to (**M**)

Book Reviews

Proceedings of the National Electronics Conference, Vol. 7

Published (1951) by National Electronics Conference, Inc., 852 E. 83 St., Chicago 19, Ill. 736 pp. incl. numerous charts, diagrams and tables. 6 × 9 in. Price $5.00.

This volume consists of the papers presented at the seventh annual National Electronics Conference held in Chicago in the fall of 1951. The topics presented cover just about the entire field of modern electronics as can be seen by the subsequent listing of subjects, and are extremely timely to anyone working in the field. Your reviewer found at least a dozen papers that had direct bearing on immediate problems.

The subjects covered include servo theory, electron tubes, information theory, audio systems, signal detection, components, high-frequency measurements and propagation, computers, magnetic amplifiers, circuit analysis, industrial electronics, television, and medical applications.

The editors of the volume are to be commended for a fine job in taking the numerous papers from different authors on various topics and organizing them so as to maintain continuity, especially in style. This represents a continuation of the good work done in the previous volumes of this series.

The book is printed clearly and the illustrations are very legible.

This well prepared and edited volume of the Conference papers will serve either as a well reported summary to those who were unable to attend the meeting, or as a convenient reference volume for those who were there. It would be very desirable if other major conferences would publish similar proceedings.—*H. I. Zagor,* General Precision Laboratory, Inc., Pleasantville, N.Y.

Professional Training of Film Technicians

By Jean Lods. Published (1951) by UNESCO, Paris. Distributed in U.S.A. by: Columbia Univ. Press, 2960 Broadway, New York 27, N.Y. 155 pp. $8\frac{5}{8} \times 5\frac{1}{4}$ in. Price $1.00.

A valuable addition to the Press, Film and Radio Series of studies sponsored by the United Nations Educational, Scientific and Cultural Organization, this brochure surveys a field whose importance has only recently been recognized in this country.

Its author is a distinguished French film director, cofounder and Deputy Director-General of the *Institut des Hautes Etudes Cinématographiques*, a Government-subsidized postgraduate school devoted to the teaching of film aesthetics and crafts.

In the ten countries investigated, states Mr. Lods, "professional training is directly conditioned . . . by the situation, organization and tendencies of the national film industry." The latter, he finds, is divided into three main types, depending on the degree of government control.

This control may vary considerably, but the author points out the universally admitted fact that "the quality of national film production is a matter of concern to the entire country." Therefore, national prestige is closely related to the competence of film technicians and their professional training.

In this respect, the high standards of the French *Institut* can be judged by the following question asked at the competitive entrance examination for art directors: "Voltaire's 'smile' is often mentioned. Define and analyze this smile on the basis of *Candide*. Relate it to a frame of mind generally characteristic of the 18th century."—*George L. George*, Screen Directors Guild, 133 E. 40 St., New York 16, N.Y.

Fluorescent Lighting

By W. Elenbaas, J. Funke, Th. Hehenkamp, L. C. Kalff, A. A. Kruithof, J. L. Ouweltjes, L. M. C. Touw, D. Vermeulen and R. Van Der Veen. Edited by C. Zwikker. Published (1952) by N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands. Distributed in U.S.A. by Elsevier Press, Inc., 402 Lovett Blvd., Houston 6, Tex. i-x + 244 pp. + 4 pp. index. 180 illus. + 23 photos. 6 × 9 in. Price $6.25.

The book reviews the scientific fundamentals of the design and operations of fluorescent lamps and accessory equipment, in terms of types and sizes used in Europe. Chapters on fixtures and fluorescent lighting applications are likewise a report of European practice.

The section on color and color renditions is a good summary of the fundamental technology involved. The spectral data on fluorescent sources, however, are based on lamps manufactured in the Netherlands. Motion picture and television engineers will find the book a convenient way to compare European practice with U.S. practice as reported in books and periodicals published in this country.—*C. L. Amick*, Lamp Div., General Electric Co., Nela Park, Cleveland 12, Ohio.

The Recording and Reproduction of Sound (2d ed.)

By Oliver Read. Published (1952) by Howard W. Sams & Co., Indianapolis 1, Ind. i-xv + 708 pp. + 70 pp. appendix + 10 pp. index. 708 illus. 6 × 9 in. Price $7.95.

This volume contains a large amount of information which should be of interest to audio hobbyists and engineers in audio and related fields. The sections on disc recording and reproducing systems are quite complete and magnetic recording is also covered in considerable detail, although no mention is made of recording on "stripe" tracks on 8mm or 16mm films. Photographic recording is barely mentioned. Public address amplifiers and sound systems are treated at some length, as are microphones and loudspeakers.

Much space is given to reprints of manufacturer's bulletins, which may be of interest to those using the particular equipment described. The NARTB Disc and Magnetic Recording Standards are reproduced in full and numerous tables and glossaries add to the usefulness of this enlarged edition.—*Clyde R. Keith*, 5 North Ter., Maplewood, N.J.

SMPTE Lapel Pins

The Society will have available for mailing after September 15, 1952, its gold and blue enamel lapel pin, with a screw back. The pin is a ½-in. reproduction of the Society symbol — the film, sprocket and television tube — which appears on the *Journal* cover.

The price of the pin is $4.00, including Federal Tax; in New York City, add 3% sales tax.

Positions Wanted

Photographic Chemist: 3 yr. experience black-and-white and color film laboratory practice and quality control. Familiar with all commercial color processes and sensitometry. Have conducted research in new processing methods. Position desired in research or development on new products and processes. Will relocate. Write M-52, c/o Lichtig, 3758 Tenth Ave., New York 34, N.Y.

Production, TV or Motion Picture: NYU BA in motion picture and TV production; participated in productions as director and unit mgr; experience as motion picture sensitometrist; at present motion picture negative assembler and cutter; worked swing shift while attending college; licensed 35mm projectionist; single, 29, veteran, resume on request; go anywhere. Harold Bernard, 560 Eastern Pkwy, Brooklyn 25, N.Y.

Meetings

72nd Semiannual Convention of the SMPTE, Oct. 6-10, Hotel Statler, Washington, D. C.

Other Societies

University Film Producers Association, Annual Meeting, Aug. 11–15, Syracuse University, Syracuse, N. Y.

Photographic Society of America, Annual Convention, Aug. 12–16, Hotel New Yorker, New York

American Institute of Electrical Engineers, Pacific General Meeting, Aug. 19–22, Hotel Westward Ho, Phoenix, Ariz.

International Society of Photogrammetry, Conference, Sept. 4–13, Hotel Shoreham, Washington, D.C.

American Standards Association, Third National Standardization Conference, Sept. 8–10, Museum of Science and Industry, Chicago, Ill.

Illuminating Engineering Society, National Technical Conference, Sept. 8–12, Edgewater Beach Hotel, Chicago, Ill.

Biological Photographic Association, Annual Meeting, Sept. 10–12, Hotel New Yorker, New York

National Electronics Conference, Annual Meeting, Sept. 29–Oct. 1, Sherman Hotel, Chicago, Ill.

Optical Society of America, Oct. 9–11, Hotel Statler, Boston, Mass.

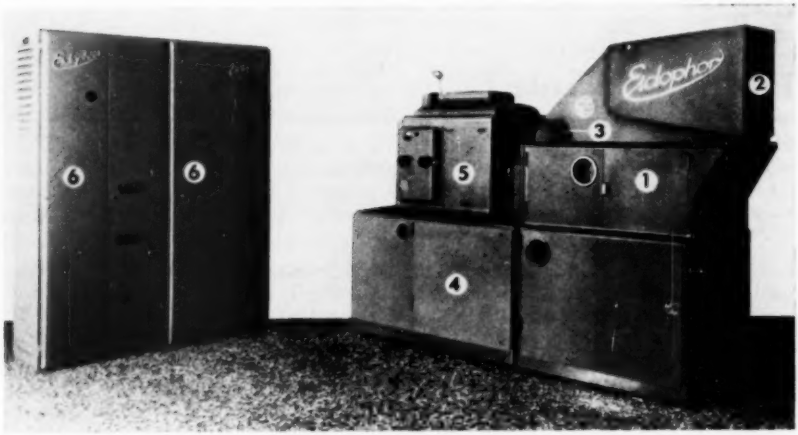
American Institute of Electrical Engineers, Fall General Meeting, Oct. 13–17, New Orleans, La.

American Standards Association, Annual Meeting, Nov. 19, Waldorf-Astoria, New York

Motion pictures in color depend on the engineers' knowledge of the "Principles of Color Sensitometry." A 72-page article bearing that title and prepared by the Color Sensitometry Committee appeared in the *Journal* for June 1950. Attractive reprint copies may be purchased for $1.00.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.



Eidophor large-screen, color-television projection equipment: (1) Eidophor projector; (2) projection light beam hood; (3) color wheel; (4) auxiliary services (vacuum pump, thermostat, and system for Eidophor cooling); (5) projection lamp (Ventarc-type); and (6) television receiver circuits.

Eidophor large-screen, color-television projection equipment has been installed in the 20th Century-Fox Film Corp. motion picture theater at 444 W. 56th St., New York City, with demonstrations for the press and invited public beginning on June 25. A 30-min program of great variety and color was originated and transmitted from the sound stages of Movietonews at W. 54 St. and Tenth Ave.

Journal readers may recall the article by E. Labin in the April 1950 *Journal* when the Eidophor was described as occupying two floors. Work toward the Eidophor was described as early as 1941 by Hugo Thiemann and by Prof. Fritz Fischer who directed the project until his death in 1948. The Eidophor was developed at the Polytechnical Institute of Zurich, Switzerland, and was brought to this country in part through the efforts of Dr. Edgar Gretener A.G. of Zurich, and by Dr. Thiemann who was on hand to answer questions during the demonstrations at Twentieth Century-Fox.

The present Eidophor projector is about the size, weight and shape of a standard motion picture projector. The Eidophor has a Ventarc-type projection lamp which was demonstrated at the Society's Convention at Chicago in 1950 and described in the October 1950 *Journal*. The Columbia Broadcasting System's field-sequential color process has been combined with the Eidophor black-and-white equipment. The CBS system was completely described in, among other places, the October 1951 *Journal* by Goldmark, Christensen and Reeves.

Converting the original black-and-white Swiss system to the color demonstrated and getting the present model developed and installed has been under the direction of Earl I. Sponable, with notable assistance from Hubert J. Schlafly, Lorin D. Grignon and William F. Jordan.

Society of Motion Picture and Television Engineers

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Neighborhood Theatre, Inc.
Neumade Products Corp.
Northwest Sound Service, Inc.
Producers Service Co.
Radiant Manufacturing Corporation
Radio Corporation of America, RCA Victor Division
Reid H. Ray Film Industries, Inc.
Reeves Sound Studios, Inc.
S.O.S. Cinema Supply Corp.
SRT Television Studios
Technicolor Motion Picture Corporation
Terrytoons, Inc.
Theatre Holding Corporation
Titra Film Laboratories, Inc.
United Amusement Corp., Ltd.
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
Wollensak Optical Company